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# Review and Assessment of Deep-Well Injection of Hazardous Waste. Volume II Appendices A, B, and C

Louis R. Reeder and Associates, Tulsa, Okla

Prepared for

Municipal Environmental Research Lab, Cincinnati, Ohio Solid and Hazardous Waste Research Div

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This four volume report is a review and assessment of the adequacy of deep-well waste injection systems to receive hazardous wastes and to define what effects that these wastes will have upon the environment when injected into subsurface reservoirs. All aspects of deep-well injection systems have been touched upon.

A comprehensive bibliography, chemical waste profiles, deep-well inventory, case histories, microbiological research, deep-well and hazardous waste research, legal aspects and an inventory of statues and regulations governing waste injection are discussed in the text and detailed in the appendices.

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# REVIEW AND ASSESSMENT OF DEEP-WELL INJECTION OF HAZARDOUS WASTE

## Volume II - Appendices A, B, & C

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This report has been reviewed by the Municipal Environmental Research Laboratory, U. S. Environmental Protection Agency, and approved for publication. Approval does not signify that the contents necessarily reflect the views and policies of the U. S. Environmental Protection Agency, nor does mention of trade names or commercial products constitute endorsement or recommendation for use.

# FOREWORD

The Environmental Protection Agency was created because of increasing public and government concern about the dangers of pollution to the health and welfare of the American people. Noxious air, foul water, and spoiled land are tragic testimony to the deterioration of our natural environment. The complexity of that environment and the interplay between its components require a concentrated and integrated attack on the problem.

Research and development is that necessary first step in problem solution and it involves defining the problem, measuring its impact, and searching for solutions. The Municipal Environmental Research Laboratory develops new and improved technology and systems for the prevention, treatment, and management of wastewater and solid and hazardous waste pollutant discharges from municipal and community sources, for the preservation and treatment of public drinking water supplies, and to minimize the adverse economic, social, health, and aesthetic efforts of pollution. This publication is one of the products of that research; a most vital communications link between the researcher and the user community.

This contract was supported by the EPA to provide a comprehensive review and data compilation of deep-well injection as a control and disposal technology for hazardous waste. Because of the large amount of information resulting from this contract, the report is divided into four volumes. Readers interested only in the general information about deep-wells are referred to Volume I. Those interested in the detailed data compiled during this work are referred to the remaining volumes in addition to Volume I. The information is providing input into the EPA's program for assessing control technologies available for managing the Nation's large quantities of hazardous materials.

Francis T. Mayo, Director
Municipal Environmental Research
Laboratory

# ABSTRACT

A review and analysis of the available information related to deep-well injection, and an assessment as to the adequacy of this method for managing hazardous wastes and ensuring protecting the environment was made.

One hundred-five deep-well related research projects were identified and hazardous waste research projects numbered 186. More than 1,000 papers related to deep-well injection of industrial waste were reviewed.

Geologic and engineering data are available in many areas to locate, design and operate a deep-well system receiving hazardous wastes. The most serious problems encountered are because of failure to use available geologic information and accepted and proven engineering practices in design and completion. A small group of waste chemicals with high human and ecological hazard ratings, little known degradability characteristics or long persistence times are identified as undesirable for injection unless containment within the host reservoir is certain.

There is a paucity of information on salaquifer chemistry, and the chemical and microbiological reactions of waste within a receiving salaquifer. Monitoring of deep-well systems needs to be developed into a predictive tool to be fully effective.

State statutes and regulations vary greatly on deep-well injection. To alleviate any problems arising from the use of interstate aquifers for injection, and for more effective management and control of deep-well systems, a standardization of regulations is considered necessary.

This report was submitted in fulfillment of EPA Contract 68-03-2101. The report is comprised of 4 volumes; the main text, Appendices A through C, Appendix D, and Appendices E through J. This volume is comprised of Appendices A, B, and C. Appendix A is the Bibliography of literature used during the study. Appendix B is a compilation of patents related to deep-well systems.

Appendix C provides available chracterization profiles of chemical wastes being injected into deep-wells. Other volumes provide the main text and additional appendices of detailed data.

As a result of EPA review of this document, there were a number of questions and issues raised as to the conclusions made versus those warranted based upon available information. The user is referred to Appendix J for additional information resulting from this review and the contractors' response to that review.

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# SECTION XI

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# SECTION XI

## APPENDIX C

## WASTE CHARACTERIZATION PROFILES

The information contained in these profiles was obtained from various sources[1,2,3,4]. They contain detailed information, where available, about the chemicals which are contained in waste streams being injected into deep-well disposal systems. The chemicals are listed alphabetically in the Table of Contents for this Appendix.

The hazard ratings which have been used in these profiles were developed by Booz-Allen Research, Inc.[1] The key to the rating system is:

3 = Severely hazardous

2 = Slight to moderate hazard

1 = Minimal hazard

U = Effects unknown

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## ACETALDEHYDE, ACETONE, METHYL ETHYL KETONE

### ACETALDEHYDE

CHEMICAL FORMULA:
$CH_3{-}\overset{O}{C}{-}H$

GENERAL DESCRIPTION: Colorless, fuming, flammable liquid. IUC Name: Ethanal. Also called acetic aldehyde and aldehyde.

Molecular Wt.: 44.05 Melting Pt.: -123.5°C Boiling Pt.: 20.8°C
Density: (Liquid) 0.7827 g/cc @ 20°C (Gas) 1.52 g/l
Vapor Pressure:
Flash Pt.: -36° F (CC) Autoignition Temperature: 365° F
Explosive Limits in Air (Wt%): Lower 4.0% Upper 57%
Solubility:
Hot Water: Miscible Cold Water: Miscible Ethanol: Miscible
Other:
DOT Classification: Flammable liquid, red label
Coast Guard Classification: Red label

### ACETONE

CHEMICAL FORMULA:
$CH_3\overset{O}{C}{-}CH_3$

GENERAL DESCRIPTION: Colorless, flammable liquid. IUC Name: 2-Propanone. Also called dimethyl ketone.

Molecular Wt.: 58.08 Melting Pt.: -94.6°C Boiling Pt.: 56.48°C
Density: (Liquid) 0.7972 g/cc @ 15° C (Gas) 2.00 g/l
Vapor Pressure: 400 mm @ 39.5°C
Flash Pt.: 0° F (CC) Autoignition Temperature: 1000° F
Explosive Limits in Air (Wt%): Lower 2.6% Upper 12.8%
Solubility:
Hot Water: Miscible Cold Water: Miscible Ethanol: Miscible
Other: Miscible DMF, chloroform, ether
DOT Classification: Flammable liquid, red label
Coast Guard Classification: Red label DCA warning label

### METHYL ETHYL KETONE

CHEMICAL FORMULA:
$C_2H_5\overset{O}{C}{-}CH_3$

GENERAL DESCRIPTION: Colorless liquid, IUC Name: 2 Butanone. Also called MEK and ethyl methyl ketone.

Molecular Wt.: 72.10 Melting Pt.: -85.9°C Boiling Pt.: 79.57°C
Density: (Liquid) 0.806 g/cm @ 20° C (Gas) 2.41 g/l
Vapor Pressure: 71.2 mm @ 20° C
Flash Pt.: 22° F (TOC) Autoignition Temperature: 960° F
Explosive Limits in Air (Wt%): Lower 1.8% Upper 10%
Solubility:
Hot Water: 19 g/100 ml @ 90°C Cold Water: 35.3 g/100 ml @ 10°C
Ethanol: Infinitely soluble Other: Ether
DOT Classification: Flammable, red label
Coast Guard Classification: Red label

MANUFACTURE: Catalytic oxidation or dehydration of the corresponding alcohol.

USE: Solvents and intermediates in the manufacture of chemicals and synthetic resins.

TOXICOLOGY. Narcotic and anesthetic. Highly irritating to the eyes and the mucous membranes of the respiratory tract. May affect the lungs. Ingestion causes nausea, vomiting, headaches and dizziness and has irritating effect.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC are:

| MATERIAL | TLV | | MAC |
|---|---|---|---|
| | ppm | $mg/M^3$ | ppm |
| Acetaldehyde | 100 | 180 | 200 |
| Acetone | 1000 | 2400 | 1000 |
| Methyl Ethyl Ketone | 200 | 590 | 250 |

The Booz-Allen Ratings for these materials are:

| COMPOUND | HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Acetaldehyde | 2 | 2 | 2 | 3 | 3 | 2 | 2 | 1 | 2 |
| Acetone | 2 | 2 | 1 | 2 | 1 | 2 | 2 | 1 | U |
| Methyl Ethyl Ketone | 2 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 2 |

OTHER HAZARDS: Potential fire hazards.

HANDLING, STORAGE TRANSPORTATION: These materials should be handled in a well ventilated area and protective clothing and respirators are recommended. In case of accidental contact, all contaminated clothing should be removed and the skin washed thoroughly with soap and water.

DISPOSAL/REUSE: In some processes recycling is possible in others the materials are not recoverable. Many processes result in dilute waste streams which have a high chemical and biological oxygen demand. They can be treated on-site or discharged into municipal sewers.

Recommended Provisional Limits for these carbonyl compounds are as follows:

| Contaminant in Air | Provisional Limit | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M3 | |
| Acetaldehyde | 1.0 | 1.8 | 0.01 TLV |
| Acetone | 10 | 24 | 0.01 TLV |
| Methyl Ethyl Ketone | 2 | 5.9 | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limit ppm (mg/l) | Basis for Recommendation |
|---|---|---|
| Acetaldehyde | 9.0 | Stokinger & Woodward Method |
| Acetone | 60.0 | Stokinger & Woodward Method |
| Methyl Ethyl Ketone | 29.5 | Stokinger & Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

Recycling is the best practice when possible.

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Treatment to reduce chemical and biological oxygen demand. Discharge into sewers. | Satisfactory |
| Incineration | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES:

These aliphatic carbonyl compounds are not considered to be candidate waste stream constituents for National Disposal Site treatment.

# ACETIC ACID, FORMALDEHYDE, SODIUM FORMATE

## ACETIC ACID

CHEMICAL FORMULA:
$CH_3-\overset{O}{\overset{\|}{C}}-OH$

GENERAL DESCRIPTION: Colorless corrosive liquid. IUC Name: Ethanoic Acid. Also called vinegar acid, methane carboxylic acid.

Molecular Wt.: 60.05 Melting Pt.: 16.7°C Boiling Pt.: 118°C
Density: (Liquid) 1.049 g/cc @ 25° C (Gas) 2.07 g/l
Vapor Pressure: 11.4 mm @ 20° C
Flash Pt.: 109° F (CC) Autoignition Temperature: 800° F
Explosive Limits in Air (Wt%): Lower 5.4% Upper 16.0% @ 212°F
Solubility:
Hot Water: Miscible Cold Water: Miscible Ethanol: Miscible
Other: Miscible glycerol, carbon tetrachloride, very slightly soluble in carbon disulfide.
IATA Classification: Corrosive liquid, white label
Coast Guard Classification: Combustible liquid

MANUFACTURE: From acetaldehyde by catalytic oxidation in either batch, continuous batch or gas phase processes, by catalytic gas phase oxidation of butane or by the destructive distillation of wood.

USES: To make cellulose acetate (47%), vinyl acetate (25%), and other acetates (16%), miscellaneous uses (12%).

## FORMALDEHYDE

CHEMICAL FORMULA:
$H\overset{O}{\overset{\|}{C}}H$

GENERAL DESCRIPTION: Colorless gas. IUC Name: Methanal. Also called oxomethane.

Molecular Wt.: 30.03 Melting Pt.: -92°C Boiling Pt.: -19.5°C
Density: (Liquid) 0.815 g/cc @ 20° C (Gas) 1.067 g/l
Vapor Pressure:
Flash Pt.: Autoignition Temperature: 572° F
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: 55% Ethanol: Soluble
Other:
DOT Classification:
Coast Guard Classification:

MANUFACTURE: By the catalytic oxidation of methanol at 300 to 600° C using a silver-copper or iron-molybdenum-vanadium catalyst. Gaseous formaldehyde polymerizes readily and is sold only in aqueous solutions.

USES: To make resins (60%), pentaerythritol (9%), ethylene glycol (13%), hexamethylenetetramine (5) and miscellaneous items (14%)

## SODIUM FORMATE

CHEMICAL FORMULA:
$H-C(=O)-ONa$

GENERAL DESCRIPTION: Colorless crystalline solid. Neutral, pH 7, in aqueous solution.

Molecular Wt.: 68.02 Melting Pt.: 253°C Boiling Pt.: ________
Density: (Solid) 1.92 g/cc @ 20°C (Gas) ________
Vapor Pressure: ________
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Wt%): Lower ________ Upper ________
Solubility:
Hot Water: Very soluble Cold Water: Very Sol. Ethanol: Slightly
Other: Soluble in glycerol
DOT Classification: ________
Coast Guard Classification: ________

MANUFACTURE: By the reaction of carbon monoxide with sodium hydroxide at 100 to 150 psi.

USES: Major use is to make formic acid which is used for textile dyeing and finishing, chemical synthesis and in the leather industry.

TOXICOLOGY: Acetic acid and its derivatives are irritants and corrosive on contact with tissue, particularly the eyes and upper respiratory tract. Ingestion causes a burning sensation pain in the stomach followed by nausea and vomiting. Contact with the skin causes reddening followed by wrinkling and peeling. Repeated contact can cause dermatitis.

Formaldehyde solution causes irritation. If swallowed, it causes violent vomiting and diarrhea which can lead to collapse and death. Repeated skin contact can cause dermatitis.

Sodium formate dust causes irritation of the eyes and the upper respiratory tract. Continued contact may cause ulcerations of the respiratory tract and skin lesions characterized by cracking and fissuring of the skin.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) are:

| COMPOUND | TLV |  | MAC |
|---|---|---|---|
|  | ppm | mg/M$^3$ | ppm |
| Acetic Acid | 10 | 25 | - |
| Formaldehyde | 5 | 6 | 5 |
| Sodium Formate | 5 | 9<br>(as free acid) | - |

The Booz-Allen Ratings on these compounds are as follows:

|  | HUMAN |  |  | ECOLOGICAL |  |  | EXPLOSION |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Acetic Acid | 2 | 2 | 2 | 1 | 3 | 2 | 2 | 1 | U |
| Formaldehyde | 3 | 3 | 3 | 2 | 3 | U | 2 | 1 | 2 |
| Sodium Formate | 3 | 3 | 3 | U | 2 | U | 1 | 1 | 1 |

OTHER HAZARDS: No others known.

HANDLING, STORAGE, TRANSPORTATION: Handle in a well ventilated area. Protective clothing and respirators are recommended. In case of contact, all contaminated clothing should be removed instantly and the skin washed thoroughly with soap and water. Showers and eye fountains must be available for serious accidents. In case of eye contact wash with large amounts of water.

Store in a cool, dry, well ventilated area, away from fire hazards.

DISPOSAL/REUSE: The uses of these materials are such that there is a high degree of utilization due to recycling of unreacted materials. The main source of waste being scrubbing to remove trace amounts.

Recommended Provisional Limits for these compounds are:

| Contaminant in Air | Provisional Limit |  | Basis for Recommendation |
|---|---|---|---|
|  | ppm | mg/M$^3$ |  |
| Acetic Acid | 0.10 | 0.25 | 0.01 TLV |
| Formaldehyde | 0.05 | 0.06 | 0.01 TLV |
| Sodium Formate | - | 0.09<br>(as free acid) | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Acetic Acid | 1.25 | Stokinger and Woodward Method |
| Formaldehyde | 0.15 | Stokinger and Woodward Method |
| Sodium Formate | 0.45<br>(as free acid) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Recycling | Best choice when possible |
| Treatment of waste water to reduce biological and chemical oxygen demand. On site or at municipal waste treatment systems. | Satisfactory |
| Incineration | Satisfactory |

Process modifications in production have substantially reduced the amounts of wastes produced.

APPLICABILITY TO NATIONAL DISPOSAL SITES: Acetic acid, formaldehyde and sodium formate can be adequately treated by common industrial and municipal techniques. They are not considered to be candidate waste stream constituents for National Disposal Sites.

# ALIPHATIC AND AROMATIC HYDROCARBONS

## ALIPHATIC
ACETYLENE, BUTANE, CYCLOHEXANE, ETHANE, ETHYLENE

## AROMATIC
BENZENE, CUMENE, XYLENE

### ACETYLENE

CHEMICAL FORMULA: $CH \equiv CH$

GENERAL DESCRIPTION: Colorless, flammable Gas, garlic like odor, IUC Name: Ethyne. Sublimes at -84.0°C Forms explosive compounds with copper and silver.

Molecular Wt.: 26.04 Melting Pt.: -81.8°C Boiling Pt.: -84.0°C sublimes
Density: (Liquid) (Gas) 1.173 g/l @ 0° C
Vapor Pressure: 44 atm @ 16.8°C
Flash Pt.: 0°F (CC) Autoignition Temperature: 571°F
Explosive Limits in Air (Wt%): Lower 2.5% Upper 80%
Solubility:
Hot Water: - Cold Water: Slightly Ethanol: +
Other: Ether, benzene, acetone
DOT Classification: Flammable gas, red gas label
Coast Guard Classification: Red gas label

### BUTANE

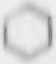
CHEMICAL FORMULA: $CH_3(CH_2)_2CH_3$

GENERAL DESCRIPTION: Colorless, flammable gas. IUC Name: n-Butane.

Molecular Wt.: 58.1 Melting Pt.: -138.6°C Boiling Pt.: -0.5°C
Density: (Liquid) 0.599 g/cm @ 0° C (Gas) 2.046 g/l
Vapor Pressure: 2 atm @ 18.8°C
Flash Pt.: -76° F (CC) Autoignition Temperature: 761°F
Explosive Limits in Air (Wt%): Lower 1.9% Upper 8.5%
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Soluble
Other: Ether, chloroform,
DOT Classification: Flammable, red gas label
Coast Guard Classification: Red gas label

## CYCLOHEXANE

CHEMICAL FORMULA: $C_6H_{12}$,



GENERAL DESCRIPTION: Colorless, flammable gas. Also called hexamethylene.
Molecular Wt.: 84.15 Melting Pt.: 6.5°C Boiling Pt.: 80.7°C
Density: (Liquid) .7791 g/cc @ 20° C (Gas) 2.90 g/l
Vapor Pressure: 100 mm @ 60.8°C
Flash Pt.: -4° F Autoignition Temperature: 500° F
Explosive Limits in Air (Wt%): Lower 1.3% Upper 8.4%
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Soluble
Other: Ether
DOT Classification: Flammable red label
Coast Guard Classification: Red label

## ETHANE

CHEMICAL FORMULA: $CH_3CH_3$

GENERAL DESCRIPTION: Colorless, flammable gas. Also called dimethyl
Molecular Wt.: 30.07 Melting Pt.: -172°C Boiling Pt.: -88.6°C
Density: (Liquid) 0.561 g/cc @ -100°C (Gas) 1.04 g/l
Vapor Pressure:
Flash Pt.: Autoignition Temperature: 959°F
Explosive Limits in Air (Wt%): Lower 3.0% Upper 12.5%
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Slightly
Other:
DOT Classification: Flammable, red label
Coast Guard Classification: Red gas label

## ETHYLENE

CHEMICAL FORMULA: $CH_2 = CH_2$

GENERAL DESCRIPTION: Colorless, flammable gas. IUC Name: Ethene. Also called etherin.
Molecular Wt.: 28.05 Melting Pt.: -169.4°C Boiling Pt.: -103.9°C
Density: (Liquid) 0.566 g/cc @ -102°C (Gas) 1.26 g/l
Vapor Pressure:
Flash Pt.: Autoignition Temperature: 842°F
Explosive Limits in Air (Wt%): Lower 3.1% Upper 32%

Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Slightly
Other: Ether
DOT Classification: Flammable, red label
Coast Guard Classification: Red label

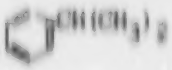
## BENZENE

CHEMICAL FORMULA: $C_6H_6$,

GENERAL DESCRIPTION: Flammable liquid. Also called benzol and coal naphtha.
Molecular Wt.: 78.11 Melting Pt.: 5.51°C Boiling Pt.: 80.093°C
Density: (Liquid) 0.8794 g/cc @ 20° C (Gas) 2.77 g/l
Vapor Pressure: 100 mm @ 26.1°C
Flash Pt.: 12°F (CC) Autoignition Temperature: 1044° F
Explosive Limits in Air (Vol%): Lower 1.3% Upper 7.1%
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Miscible
Other: Chloroform, ether, acetone.
DOT Classification: Flammable, red label
Coast Guard Classification: Red label

## CUMENE

CHEMICAL FORMULA: $C_6H_5CH(CH_3)_2$,



GENERAL DESCRIPTION: Liquid. IUC Name: Isopropylbenzene. Also called cumol, 2-phenylpropane.
Molecular Wt.: 120.19 Melting Pt.: -96.0°C Boiling Pt.: 152° C
Density: (Liquid) 0.864 g/cc @ 20° C (Gas) 4.1 g/l
Vapor Pressure: 10 mm @ 38.3° C
Flash Pt.: 111° F Autoignition Temperature: 795° F
Explosive Limits in Air (Vol%): Lower 0.9% Upper 6.5%
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Soluble
Other:
DOT Classification:
Coast Guard Classification:

## XYLENE

Three isomers exist. meta-xylene, ortho-xylene and para-xylene

## m - XYLENE

CHEMICAL FORMULA: $C_6H_4(CH_3)_2$;

GENERAL DESCRIPTION: Colorless flammable liquid. IUC Name: 1,3 - dimethyl benzene. Also called m-xylol.

Molecular Wt.: 106.2 Melting Pt.: -47.9°C Boiling Pt.: 139°C

Density: (Liquid) 0.864 g/cc @ 20° C (Gas) 3.66 g/l

Vapor Pressure: 10 mm @ 28.3°C

Flash Pt.: Autoignition Temperature: 982° F

Explosive Limits in Air (Wt%): Lower 1.1% Upper 7.0%

Solubility:

Hot Water: Insoluble Cold Water: Insoluble Ethanol: Miscible

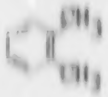
Other: Ether

DOT Classification: Flammable, red label

Coast Guard Classification: Red label

## o-XYLENE

CHEMICAL FORMULA: $C_6H_4(CH_3)_2$;



GENERAL DESCRIPTION: Colorless flammable liquid. IUC Name: 1,2 -dimethyl benzene. Also called o-Xylol.

Molecular Wt.: 106.2 Melting Pt.: -25.5°C Boiling Pt.: 144.4°C

Density: (Liquid) 0.880 g/cc @ 32.1°C (Gas) 3.66 g/l

Vapor Pressure: 10 mm @ 32.1°C

Flash Pt.: 90°F Autoignition Temperature: 867° F

Explosive Limits in Air (Wt%): Lower 1.0% Upper 6.0%

Solubility:

Hot Water: Insoluble Cold Water: Insoluble Ethanol: Miscible

Other: Ether

DOT Classification: Flammable, red label

Coast Guard Classification: Red label

## p-XYLENE

CHEMICAL FORMULA: $C_6H_4(CH_3)_2$;

GENERAL DESCRIPTION: Colorless flammable liquid. IUC Name: 1,4 dimethyl benzene. Also called p-xylol.

Molecular Wt.: 106.2 Melting Pt.: 13.2°C Boiling Pt.: 138.3°C
Density: (Liquid) 0.86 gm/cc @ 20° C (Gas) 3.66 g/l
Vapor Pressure: 10 mm @ 27.3°C
Flash Pt.: 103° F (C) Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower 1.1% Upper 7.0%
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Soluble
Other: Ether
DOT Classification: Flammable, red label
Coast Guard Classification: Red label

MANUFACTURE: Saturated hydrocarbons and small amounts of benzene and unsaturated aliphatics are isolated directly from petroleum by distillation. The alkenes are usually made from the corresponding saturated material by dehydration at high temperatures over chromia-alumina catalysts.

USES: Saturated aliphatic and aromatic hydrocarbons are used as fuels, solvents reaction media and in formulations of many industrial and consumer items. Alkenes and alkene dimers and trimers are used either to produce polymers or to make other monomers.

TOXICOLOGY: Aliphatics are simple asphyxiant gases having no toxic effect, but acting to exclude oxygen from the lungs. Lower boiling hydrocarbons can cause frostbite when spilled on the skin. Repeated contact with the skin can cause irritation.

Aromatics are poisonous through inhalation, ingestion or skin absorption. Strongly irritating to skin, producing erythema, burning, and in severe cases edema. High vapor concentration is similar to other anesthetic gases. Chronic exposure produces toxic action on blood forming tissue.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) that have been established are:

| Aliphatic Hydrocarbons | TLV |  | MAC |
|---|---|---|---|
|  | ppm | mg/M³ | ppm |
| Acetylene | - | - | - |
| Butane | 500 | 1200 | - |
| Cyclohexane | 300 | 1050 | 400 |
| Ethane | - | - | - |
| Ethylene | - | - | - |
| Aromatic Hydrocarbons |  |  |  |
| Benzene | 25 | 80 | 25 |
| Cumene | 50 | 245 | 100 |
| Xylene | 100 | 435 | 200 |

The Booz-Allen Ratings for these hydrocarbons are:

| Aliphatic Hydrocarbons | HUMAN |  |  | BIOLOGICAL |  |  | EXPLOSION |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Acetylene | 1 | 1 | 1 | 1 | 2 | 1 | 2 | 1 | 2 |
| Butane | 2 | 1 | 1 | 1 | 1 | 0 | 2 | 1 | 2 |
| Cyclohexane | 1 | 1 | 1 | 1 | 1 | 0 | 2 | 1 | 2 |
| Ethane | 2 | 1 | 1 | 1 | 0 | 0 | 2 | 1 | 1 |
| Ethylene | 2 | 1 | 1 | 2 | 1 | 0 | 2 | 1 | 2 |

| Aromatic Hydrocarbons | HUMAN |  |  | BIOLOGICAL |  |  | EXPLOSION |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Benzene | 2 | 2 | 2 | 1 | 1 | 0 | 2 | 1 | 2 |
| Cumene | 1 | 1 | 1 | 1 | 1 | 0 | 2 | 1 | 2 |
| Xylene | 1 | 1 | 1 | 1 | 1 | 1 | 2 | 1 | 1 |

OTHER HAZARDS: All are flammable and explosive. The acetylene is especially so, and dry salts of acetylene are very prone to spontaneous detonation.

HANDLING, STORAGE, TRANSPORTATION: Care must be exercised in handling, storing, and transporting to prevent container leakage. The pure materials have very little odor, adding to the danger. Keep away from fire hazards and in a cool well-ventilated area. Areas where these materials are used should be equipped with spark proof electrical equipment. Protect from heat and sudden temperature rise.

DISPOSAL/REUSE: Most unused or unreacted material is recycled. Main sources of waste are dilute aqueous solutions resulting from washing procedures. These wastes are discharged into the sewer after skimming and primary treatment to reduce the hydrocarbon content.

Some waste is discharged directly into rivers and streams. Sludges are landfilled. Some liquid waste is incinerated.

Some waste from small users is picked up by scavengers who dispose of it by reclaiming, landfill, ocean burial, open burning or any other method that seems appropriate.

For disposal of the compounds into the environment the following Provisional Limits are recommended:

| Constituent in Air<br>Aliphatic Hydrocarbons | Provisional Limit<br>ppm | <br>mg/m³ | Basis for<br>Recommendation |
|---|---|---|---|
| Acetylene | - | 22 | Based on Similar Compounds |
| Butane | 5 | 12 | 0.01 TLV |
| Cyclohexane | 3 | 10.5 | 0.01 TLV |
| Ethane | - | 9 | Based on Similar Compounds |
| Ethylene | - | 22 | Based on Similar Compounds |
| **Aromatic Hydrocarbons** | | | |
| Benzene | 0.25 | 0.80 | 0.01 TLV |
| Cumene | 0.5 | 2.45 | 0.01 TLV |
| Xylene | 1.0 | 4.35 | 0.01 TLV |

| Constituent in<br>Water and Soil | Provisional Limits<br>ppm (mg/l) | Basis for<br>Recommendation |
|---|---|---|
| **Aliphatic Hydrocarbons** | | |
| Acetylene | 110 | Based on Similar Compounds |
| Butane | 60 | Stokinger & Woodward Method |
| Cyclohexane | 52.5 | Stokinger & Woodward Method |
| Ethane | 45 | Based on Similar Compounds |
| Ethylene | 110 | Based on Similar Compounds |
| **Aromatic Hydrocarbons** | | |
| Benzene | 3.5 | Stokinger & Woodward Method |
| Cumene | 12.25 | Stokinger & Woodward Method |
| Xylene | 4.35 | Stokinger & Woodward Method |

EVALUATION OF WASTE MANAGEMENT:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Recycling | Best Choice when possible |
| Discharge of dilute aqueous streams into the municipal or industrial sewer after preliminary treatment | Satisfactory |
| Incineration | Satisfactory |
| Landfill of residue, sludges and hydrocarbon mixtures obtained during manufacture and use | Not satisfactory due to long term threat to underground water supplies |
| Uncontrolled disposal by local scavengers | Potentially good due to concentrating of wastes at few sites |

APPLICABLE TO NATIONAL DISPOSAL SITES: All of these materials can be handled easily and safely locally by common industrial techniques, therefore, they are not considered candidates for National Disposal Sites.

## ACROLEIN

CHEMICAL FORMULA:
$CH_2{=}CH\overset{O}{\overset{\|}{C}}H$

GENERAL DESCRIPTION: Colorless, volatile unstable, flammable liquid. IUC Name: 2-propenal. Also called acrylaldehyde, acrylic aldehyde, allyl aldehyde.

Molecular Wt.: 56.06 Melting Pt.: -87.7°C Boiling Pt.: 52.5°C
Density: (Liquid) 0.841 g/cc @ 20°C (Gas) 1.44 g/l
Vapor Pressure: 760 mm @ 52.5°C; 215 mm @ 20°C; 678.5 mm @ 50°C
Flash Pt.: Autoignition Temperature: 532°F
Explosive Limits in Air (Wt%): Lower 2.8% Upper 31%
Solubility:
Hot Water: 24.0% (wt) Cold Water: 20.8% (wt) @ 20°C
Other: Soluble in ether Ethanol: Soluble
Coast Guard Classification: Flammable
DOT Classification: 28, 29

MANUFACTURE: By the direct oxidation of propylene or by the cross-condensation of acetaldehyde. Large scale commercial facilities for the manufacture of acrolein are operated by Union Carbide and Shell Chemical.

USES: In the manufacture of pharmaceuticals, amino acids, odorants, dyestuffs, textile finishing, resins, paper chemicals, polyesters, and polyurethanes.

TOXICOLOGY: Acrolein is highly toxic and is poisonous by ingestion, inhalation, and absorption through the skin. It is intensely irritating to the eyes, respiratory tract and lungs. The liquid can cause severe burns to the eyes and skin. The Threshold Limit Value quoted in the current Occupational Safety and Health Standards is 0.1 ppm. The TRW assessment of the toxicological information recommends a limit in air of 0.001 ppm (0.0025 mg/M$^3$) for 24 hour exposure.

The Booz-Allen Ratings for Acrolein are:

| HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 2 | 2 | 3 | 2 | 2 | 0 | 2 |

OTHER HAZARDS: Acrolein monomer is a dangerous substance due to its flammability and high reactivity. In addition to it being explosive between 2.8 and 31 percent by volume in air it may be subject to explosive polymerization if inadequately inhibited.

HANDLING, STORAGE, TRANSPORTATION: Acrolein requires special methods of handling. All processing equipment and storage facilities should be located outdoors to provide adequate ventilation. All electrical equipment, including flashlights, used around acrolein should be vapor tight or explosion proof. All equipment should be properly grounded. Static electricity should be guarded against. Copper metal or its alloys is recommended in distillation systems because of the inhibiting effect afforded by these metals, although iron and steel are satisfactory construction materials for handling inhibited acrolein. Acrolein should be stored under an oxygen-free atmosphere as an aid to prevent explosive polymerization. Large quantities should be stored in non-draining, diked areas. Acrolein is shipped under an oxygen-free atmosphere and inhibited with hydroquinone.

DISPOSAL/WASTE: The products formed in the neutralization of dilute streams must be considered when disposing of acrolein in aqueous waste streams. The reaction with the carbon-carbon double bond is catalyzed by base.

Current techniques use neutralization of acrolein with base and lagooning. Waste acrolein streams are too dilute for incineration, therefore, secondary treatment or deep well disposal is presently used.

In releasing acrolein to the environment the following Recommended Provisional Limits should be considered:

| Acrolein as a Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.001 ppm (0.0025 mg/M$^3$) | 0.01 TLV |
| Water and Soil | 0.01 ppm | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES: Acrolein appears in waste streams in low concentrations and only rarely as concentrated waste.

| METHODS OF DISPOSAL | EVALUATION |
|---|---|
| Return to a manufacturer for reprocessing when possible | Best Choice |
| Incineration in two stages to convert acrolein to $CO_2$ and water. | Satisfactory |
| DILUTE AQUEOUS WASTE | |
| Secondary treatment | Insufficient information to evaluate |
| Deep well disposal | Inadequate due to lack of assurance that a deep-well will operate satisfactorily over a long period; little research into long-term effectiveness and deep-well injection in real- |

| METHODS OF DISPOSAL | EVALUATION |
|---|---|
|  | ly long term storage of hazardous materials, as opposed to conversion to a non-hazardous material. |
| Combustion after evaporative concentration. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Due to its high chemical reactivity, toxicity, flammability and difficulties in processing it is anticipated that acrolein waste will require treatment at National Disposal Sites.

# ADIPIC ACID

CHEMICAL FORMULA: $HO_2C(CH_2)_4CO_2H$

PHYSICAL DESCRIPTION: Colorless crystalline solid. IUC Name: 1,6 - hexanedioic acid. Also called 1,4 - butane dicarboxylic acid.
Molecular Wt.: 146.14 Melting Pt.: 152°C Boiling Pt.: 337.5°C
Density: (Solid) 1.360 g/cc @ 25°C (Gas) 5.04 g/l
Vapor Pressure: 1 mm @ 159.5°C
Flash Pt.: 385°F (CC) Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: Soluble Cold Water: Soluble Ethanol: Soluble
Other: Methanol, acetone

MANUFACTURE: Catalytic oxidation of cyclohexanol

USES: In the production of nylon 6/6 (88%), esters for plasticizers and synthetic lubricants and in urethans.

TOXICITY: Very low.

The Booz-Allen Ratings for adipic acid are as follows:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 0 | 0 | 0 | 1 | 2 | 0 | 1 | 1 | 1 |

OTHER HAZARDS: No hazards.

HANDLING STORAGE AND TRANSPORTATION: No particular hazards

DISPOSAL/REUSE: Any unused material is recycled. Dilute waste streams can be treated on site or discharged into the municipal sewer after pH adjustment.

Recommended Provisional Limits for adipic acid are:

| Adipic Acid as Contaminant In | Provisional Limit | | Basis for Recommendation |
|---|---|---|---|
| | ppm | mg/M³ | |
| Air | - | 0.25 | Based on Similar Compounds |
| Soil and water | 1.25 | - | Based on Similar Compounds |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| Disposal Methods | Evaluation |
|---|---|
| Recycling | Best choice when possible |
| Treatment of waste to reduce chemical and biological oxygen demand, and discharge into municipal sewers | Satisfactory |
| Incineration | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Adipic acid can best be handled by municipal or industrial disposal methods and is not considered a candidate waste stream constituent for National Disposal Sites.

# ADIPONITRILE

CHEMICAL FORMULA: $CN(CH_2)_4CN$

GENERAL DESCRIPTION: Water-white liquid, practically odorless. Also calle 1,4 dicyanobutane and tetramethylene cyanide.

Molecular Wt.: 108.14 Melting Pt.: 2.3°C Boiling Pt.: 295°C
Density: (Liquid) 0.965 g/cc @ 20°C (Gas) ______
Vapor Pressure: ______
Flash Pt.: 199.4°F Autoignition Temperature: ______
Explosive Limits in Air (Vol%): Lower ______ Upper ______
Solubility:
Hot Water: ______ Cold Water: ______ Ethanol: ______
Other: ______
DOT Classification: ______
Coast Guard Classification: ______

TOXICOLOGY: Toxic since the nitrile group will behave like a cyanide when ingested or absorbed into the body by contact. It produces disturbances of the respiration and circulation, irritation of the stomach and intestines and loss of weight.

OTHER HAZARDS: Combustion products may contain hydrocyanic acid. It is a moderate fire hazard when exposed to heat or flames. When heated to decomposition, it emits highly toxic fumes. It can react with oxidizing materials.

HANDLING, STORAGE, TRANSPORTATION: Handle with care in a well ventilated area. Store away from heat, open flames and oxidizing materials. Wear protective equipment to prevent inhalation, ingestion or skin contact.

# ALCOHOLS
(Allyl Alcohol, Amyl Alcohol, Ethylene Glycol, Butanols, Glycerin)

## ALLYL ALCOHOL

CHEMICAL FORMULA: $CH_2=CH-CH_2OH$

GENERAL DESCRIPTION: Colorless liquid. Pungent odor. Polymerizes slowly on storage to a thick syrup. IUC Name: 2-Propen-1-ol
Molecular Wt.: 58.08 Melting Pt.: -129°C Boiling Pt.: 96-97°C
Density: (Liquid) 0.8540 gm/ml @ 20°C (Gas) 2.00 g/l
Vapor Pressure: 10 mm @ 10.5°C
Flash Pt.: 70°F (O.C.) Autoignition Temperature: 713°F
Explosive Limits in Air (Wt%): Lower 2.5% Upper 18%
Solubility:
Hot Water: Miscible Cold Water: Miscible Ethanol: Miscible
Other: Miscible chloroform, ether, petroleum ether
DOT Classification:
Coast Guard Classification:

## AMYL ALCOHOL

Two Isomers are Listed Here

### n-Amyl Alcohol

CHEMICAL FORMULA: $CH_3-CH_2-CH_2-CH_2-CH_2-OH$

GENERAL DESCRIPTION: Colorless liquid. IUC Name: 1-Pentanol. Also called pentyl alcohol, n-butyl carbinol
Molecular Wt.: 88.15 Melting Pt.: -79°C Boiling Pt.: 138.1°C
Density: (Liquid) 0.824 g/cc @ 20° C (Gas) 3.04 g/l
Vapor Pressure: 1 mm @ 13.6° °C 10 mm @ 44.9°C
Flash Pt.: 100° F (C.C.) Autoignition Temperature: 572°F
Explosive Limits in Air (Wt%): Lower 1.2% Upper 10% @ 100°C
Solubility:
Hot Water: Cold Water: 2.7 g/100 ml @ 22°C Ethanol: Miscible
Other:
DOT Classification:
Coast Guard Classification: Combustible liquid

### sec - Amyl Alcohol

CHEMICAL FORMULA:

$CH_3-\overset{OH}{CH}-CH_2-CH_2-CH_3$

GENERAL DESCRIPTION: Colorless liquid. IUC Name: 2- Pentanol. Also called methyl propyl carbinol
Molecular Wt.: 88.15 Melting Pt.: -50°C Boiling Pt.: 119.3°C
Density: (Liquid) 0.811 g/cc @ 20° C (Gas) 3.04 g/l
Vapor Pressure:
Flash Pt.: 105° F (O.C.) Autoignition Temperature: 650 to 725°F
Explosive Limits in Air (Wt%): Lower -- Upper 9.0%
Solubility:
Cold Water: 16.6 g/100 ml @ 20° C Hot Water: Ethanol: Miscible
Other: Miscible in ether.
DOT Classification:
Coast Guard Classification:

## BUTANOL
(There are three isomers)

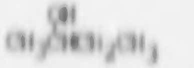
### 1- BUTANOL

CHEMICAL FORMULA: $CH_3\text{-}CH_2\text{-}CH_2\text{-}CH_2OH$

GENERAL DESCRIPTION: Colorless flammable liquid. Also called n- butyl alcohol, propyl carbinol.
Molecular Wt.: 74.12 Melting Pt.: -90°C Boiling Pt.: 117-118°C
Density: (Liquid) 0.810 g/cc @ 20°C (Gas) 2.55 g/l
Vapor Pressure: 5.5 mm @ 20°C
Flash Pt.: 36-38°C Autoignition Temperature: 689°F
Explosive Limits in Air (Wt%): Lower 1.4% Upper 11.2%
Solubility:
Cold Water: 9.1 ml/100 ml @ 25°C Hot Water: Ethanol: Miscible
Other: Miscible in ether and many other organic solvents
DOT Classification:
Coast Guard Classification:
MCA warning label

### 2- BUTANOL

CHEMICAL FORMULA:



$CH_3\overset{OH}{C}HCH_2CH_3$

GENERAL DESCRIPTION: Colorless flammable liquid. Also called sec-butyl alcohol, methyl ethyl carbinol.
Molecular Wt.: 74.12 Melting Pt.: -89°C Boiling Pt.: 99.5°C
Density: (Liquid) 0.808 g/cc @ 20°C (Gas) 2.55 g/l
Vapor Pressure: 10 mm @ 20°C
Flash Pt.: 75° F (C.C.) Autoignition Temperature: 763°F
Explosive Limits in Air (Wt%): Lower 1.7% @100°C Upper 9.8% @100° C

Solubility:
Hot Water: ________ Cold Water: 10 wt% Ethanol: miscible
Other: miscible in ether and other organic solvents
DOT Classification:
Coast Guard Classification:
MCA warning label

## tert-BUTANOL

CHEMICAL FORMULA:

$$CH_3-\overset{OH}{\underset{CH_3}{C}}-CH_3$$

GENERAL DESCRIPTION: Colorless liquid or crystalline solid. IUC Name: 2-Methyl-2-propanol
Molecular Wt.: 74.12 Melting Pt.: 25.5°C Boiling Pt.: 82.41°C
Density: (Liquid) 0.7887 g/cc @ 20°C (Gas) 2.55 g/l
Vapor Pressure: 40 mm @ 24.5°C
Flash Pt.: 52°F (O.C.) Autoignition Temperature: 892°F
Explosive Limits in Air (Wt%): Lower 2.4% Upper 8.0%
Solubility:
Hot Water: Soluble Cold Water: Soluble Ethanol: Miscible
Other: Miscible in ether
DOT Classification:
Coast Guard Classification:
MCA warning label

## ETHYLENE GLYCOL

CHEMICAL FORMULA: $HO-CH_2-CH_2-OH$

GENERAL DESCRIPTION: Colorless very hygroscopic liquid. IUC Name: 1,2-ethanediol. Also called glycol and glycol alcohol
Molecular Wt.: 102.1 Freezing Pt.: -13°C Boiling Pt.: 197.5°C
Density: (Liquid) 1.113 g/cc @ 25°C (Gas) 214 g/l
Vapor Pressure: 0.05 mm @ 20°C
Flash Pt.: 232° F (OC) Autoignition Temperature: 775° F
Explosive Limits in Air (Wt%): Lower 3.2% Upper
Solubility:
Hot Water: Miscible Cold Water: Miscible Ethanol:Miscible
Other: Soluble in lower alcohols, acetic acid, acetone, pyridine. Insoluble in benzene and its homologues, chlorinated hydrocarbons.
DOT Classification:
Coast Guard Classification:

## GLYCERIN

CHEMICAL FORMULA:
$CH_2(OH)-CH(OH)-CH_2(OH)$

GENERAL DESCRIPTION: Colorless liquid or crystalline solid. IUC Name: 1,2,3-Propanetriol. Also called glycerol. Absorbs water, $H_2S$, HCN and $SO_2$ readily.

Molecular Wt.: 92.09 Melting Pt.: 17.9°C Boiling Pt.: 290°C
Density: (Liquid) 1.260 g/cc @ 20°C (Gas) 3.17 g/l
Vapor Pressure: 0.0025 mm @ 50°C
Flash Pt.: 320° F Autoignition Temperature: 739°F
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: Miscible Cold Water: Miscible Ethanol: Miscible
Other: Soluble in ethyl acetate, ether; insoluble in benzene, chloroform, petroleum solvents.
DOT Classification: ______
Coast Guard Classification: ______

MANUFACTURE: Hydration of alkenes, synthesized from propylene and triglycerides, oxo process or hydroformulation of the alkenes.

USES: As solvents and chemical intermediates. Glycerin and glycols are used as anti-freeze and in cosmetics.

TOXICOLOGY: All are relatively non toxic except allyl alcohol. All are irritants to mucous membranes, particularly the eyes, nose and respiratory passages. Ingestion causes headache, nausea, vomiting and delerium. Repeated exposure can cause damage to the kidneys, liver and blood vessels. Allyl alcohol is a strong irritant and damage to the kidneys and liver occurs at much lower concentration.

The Threshold Limit Value (TLV) and Maximum Allowable Concentrations (MAC) are as follows:

| Compound | TLV |  | MAC |
|---|---|---|---|
|  | ppm | mg/M$^3$ | ppm |
| Allyl Alcohol | 2 | 5 | 2 |
| Amyl Alcohol | - | - | - |
| Butanols | 100 | 300 | 100 |
| Ethylene Glycol | - | - | - |
| Glycerin | 400 | 980 | 400 |

The Booz-Allen Ratings are as follows:

| COMPOUND | HUMAN<br>Air | <br>Water | <br>Land | ECOLOGICAL<br>Air | <br>Water | <br>Land | EXPLOSION<br>Air | <br>Water | <br>Land |
|---|---|---|---|---|---|---|---|---|---|
| Allyl Alcohol | 3 | 2 | 2 | 1 | 1 | U | 2 | 1 | 2 |
| Amyl Alcohol | 2 | 1 | 2 | 1 | 2 | U | 2 | 1 | 2 |
| Butanols | 1 | 2 | 1 | 1 | 3 | U | 2 | 1 | 2 |
| Ethylene Glycol | 1 | 2 | 1 | 1 | 1 | U | 2 | 1 | 1 |
| Glycerin | 1 | 1 | 1 | 1 | 1 | U | 1 | 1 | 1 |

OTHER HAZARDS: All are flammable to some degree.

HANDLING, STORAGE, TRANSPORTATION: Handle in a well ventilated area. Protective clothing and respirators are recommended. In case of contact all contaminated clothing should be removed and the skin washed thoroughly.

DISPOSAL/REUSE: In some processes, materials are recycled as much as possible. Many processes result in dilute waste streams. They can be treated on site or discharged into the municipal sewer.

For release into the environment, the following Provisional Limits are listed below:

| Contaminant in Air | Provisional Limits<br>ppm | <br>mg/M³ | Basis for Recommendation |
|---|---|---|---|
| Allyl Alcohol | 0.02 | 0.05 | 0.01 TLV |
| Amyl Alcohol | - | 3.0 | Based on similar compounds |
| Butanols | 1.0 | 3.0 | 0.01 TLV |
| Ethylene Glycol | - | 2.0 | Based on similar compounds |
| Glycerin | - | 2.0 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limits<br>ppm | Basis for Recommendation |
|---|---|---|
| Allyl Alcohol | 0.23 | Stokinger & Woodward Method |
| Amyl Alcohol | 15 | Based on Similar Compounds |
| Butanols | 15 | Stokinger & Woodward Method |
| Ethylene Glycol | 1.0 | Based on Similar Compounds |
| Glycerin | 1.0 | Based on Similar Compounds |

EVALUATION OF WASTE MANAGEMENT:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Recycling | Best choice when possible |

| | |
|---|---|
| Treatment of waste water to reduce chemical and biological oxygen demand. Discharge to sewer | Satisfactory |
| Incineration | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES:

These compounds can be handled by municipal and industrial disposal methods. They are not considered waste stream candidates for National Disposal Sites.

# ALUMINUM OXIDE, MAGNESIUM OXIDE, VANADIUM PEROXIDE, ZINC OXIDE

## ALUMINUM OXIDE

CHEMICAL FORMULA: $Al_2O_3$

GENERAL DESCRIPTION: White crystalline powder. Also called alumina.
Molecular Wt.: 101.96 Melting Pt.: 2045°C Boiling Pt.: 2980°C
Density: (Solid) 3.965 g/cc @ 25°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Insoluble Cold Water: Insoluble
Ethanol: Insoluble Other:
DOT Classification:
Coast Guard Classification:

MANUFACTURE: From aluminum hydroxide such as bauxite. The Bayer process is one method used.

USES: As an absorbent and desiccant for drying gases and liquids, as a catalyst for various chemical reactions, as abrasives, in the manufacture of refractories, in absorption chromatography, as filler for paints and varnishes, in the manufacture of alloys, ceramic materials, electrical insulators and resistors, dental cements, glass, artificial gems and in coating for metals.

## MAGNESIUM OXIDE

CHEMICAL FORMULA: MgO

GENERAL DESCRIPTION: Colorless crystalline powder. It takes up $CO_2$ and water from the air.
Molecular Wt.: 40.32 Melting Pt.: 2800°C Boiling Pt.: 3600°C
Density: (Solid) 3.58 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 0.0086 g/100 ml @ 30°C Cold Water: 0.00062 g/100 ml
Ethanol: Insoluble Other: Soluble in acids and ammonium salts.
DOT Classification:
Coast Guard Classification:

MANUFACTURE: It occurs in nature as the mineral periclase. It is manufactured by calcination of magnesium carbonate, magnesium hydroxide or by decomposition of magnesium chloride.

USES: In the manufacture of refractories, magnesium metal and oxychloride cements, as an ingredient in mixed fertilizer, in the manufacture of magnesium salts, as a neutralizing agent and vulcanization accelerator in the compounding of neoprene and other rubbers, as a decolorizing agent for solvents in the dry cleaning industry, as an absorbent and a catalyst, as an ingredient of various pharmaceutical and cosmetic formulations such as dentifrices and powders, as an antacid and laxative for man and as a laxative for young foals, calves, pigs and dogs.

## VANADIUM PENTOXIDE

CHEMICAL FORMULA: $V_2O_5$

GENERAL DESCRIPTION: Yellow to red crystalline solid.
Molecular Wt.: 181.88 Melting Pt.: 690°C Boiling Pt.: 1750°C d
Density: (Solid) 3.357 g/cc @ 18°C (Gas) ____
Vapor Pressure: ____
Flash Pt.: ____ Autoignition Temperature: ____
Explosive Limits in Air (Wt%): Lower ____ Upper ____
Solubility:
    Hot Water: ____ Cold Water: 0.8 g/cc @ 20°C
    Ethanol: Insoluble Other: ____
DOT Classification: ____
Coast Guard Classification: ____

MANUFACTURE: By carefully igniting ammonium vanadate and by slightly acidifying an alkaline, aqueous solution of ammonium vanadate.

USES: As a catalyst for various chemical reactions, particularly those involving oxidation such as the oxidation of $SO_2$ and $SO_3$ in making sulfuric acid, in the manufacture of yellow glass, and for inhibiting ultraviolet light transmission in glass, as a developer in photography, and in the manufacture of aniline black.

## ZINC OXIDE

CHEMICAL FORMULA: $ZnO$

GENERAL DESCRIPTION: White or yellowish powder. Also called chinese white and flowers of zinc.
Molecular Wt.: 81.37 Melting Pt.: 1975°C Boiling Pt.: ____
Density: (Solid) 5.47 g/cc (Gas) ____

Vapor Pressure: ______________________
Flash Pt.: ______________________ Autoignition Temperature: ______________
Explosive Limits in Air (Vol%): Lower ______________ Upper ______________
Solubility:
Hot Water: ______________________ Cold Water: 0.00015 g/100 ml @ 29° C
Ethanol: Insoluble ______________________ Other: Soluble in acids, alkalis, $NH_4Cl$
DOT Classification: ______________________
Coast Guard Classification: ______________________

MANUFACTURE: By the vaporization of metallic zinc by indirect heating in the presence of CO gas and oxidation of the zinc vapor with preheated air. It can also be produced from the zinc ore, franklinite or from zinc blende. It occurs naturally as the mineral zincite.

USES: As a pigment in white paints, in cosmetics, driers, quick-setting cements, in dental cements, in the manufacture of opaque glass and certain types of transparent glass, in the manufacture of enamels, automobile tires, white glue, matches, white printing inks, porcelains, zinc green, as an analytical chemical reagent, as an astringent, antiseptic, protective in skin diseases; in veterinary applications as a dressing in moist eczema and on wounds and otorrhea in dogs.

TOXICOLOGY: The materials included in this report are non-toxic. However inhalation of the solid particles could cause some physical damage.

Aluminum oxide is non-toxic, but it has been reported that inhalation of finely divided particles can cause physical damage to the lung.

Inhalation of freshly formed magnesium may cause metal fume fever. There is no evidence that it can produce any true systemic poisoning.

Vanadium compounds act chiefly as irritants to the conjunctivae and respiratory tracts. Prolonged exposures may lead to pulmonary involvement. Responses are acute, but never chronic.

Inhalation of fresh fumes of zinc oxide can cause a disease known as "brass founders' ague" or "brass chills". However, there is no cumulative effect to the inhalation of zinc fume. The zinc oxide dust which is not freshly formed is virtually innocuous, but it can block the ducts of the sebaceous glands and give rise to a papular, pustular eczema in men engaged in packing this compound into barrels.

The Threshold Limit Values (TLV) and Lethal Doses or Concentrations are as follows:

| Contaminant in Air | TLV | Lethal Dose or Concentration |
|---|---|---|
| Aluminum Oxide | * | - |
| Magnesium Oxide | 15 mg/M³ (fume) | - |

| Contaminant in Air | TLV | Lethal Dose or Concentration |
|---|---|---|
| Vanadium Pentoxide | 0.5 mg/M$^3$ (dust)<br>0.1 mg/M$^3$ (fume) | - |
| Zinc Oxide | 5 mg/M$^3$ (fume) | ih $LC_{LO}$: 2500 mg/M$^3$ rat |

* The proposed TLV is 10 mg/M$^3$ or 30 million particles /ft$^3$ whichever is smaller.

The Booz-Allen Ratings are:

| CONTAMINANT | HUMAN |  |  | ECOLOGICAL |  |  | EXPLOSION |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Aluminum Oxide | 2 | 1 | 1 | 1 | U | 3 | 2 | 1 | 1 |
| Magnesium Oxide | - | - | - | - | - | - | - | - | - |
| Vanadium Pentoxide | 3 | 1 | 1 | 3 | U | 3 | 2 | 1 | 1 |
| Zinc Oxide | 2 | 1 | 1 | 3 | 3 | U | 1 | 1 | 1 |

OTHER HAZARDS: No other hazards known.

HANDLING, STORAGE, TRANSPORTATION: The chief concern in handling and storage is to maintain adequate ventilation of the dust and fume by workers. Dusty materials must be shipped in plastic-coated bags to prevent pollution during transportation.

DISPOSAL/REUSE: Contaminated materials are usually disposed of rather than reprocessed for reuse. The following Provisional Limits should be considered before disposal into the environment:

| Contaminant in Air | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Aluminum Oxide | 0.1 mg/M$^3$ or<br>0.3 million particles/ft$^3$* | 0.01 TLV |
| Magnesium Oxide | 0.10 mg/M$^3$ | 0.01 TLV |
| Vanadium Pentoxide | 0.005 mg/M$^3$ (fume) | 0.01 TLV |
|  | 0.001 mg/M$^3$ (dust) | 0.01 TLV |
| Zinc Oxide | 0.5 mg/M$^3$ | 0.01 TLV |

*Whichever is the smaller

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Aluminum Oxide | 0.5 ppm (mg/l) | Stokinger and Woodward Method |
| Magnesium Oxide | 125 ppm (mg/l) as Mg | Drinking Water Standard |
| Vanadium Pentoxide | 0.05 ppm (mg/l) as V | Chronic toxicity |
| Zinc Oxide | 5 ppm (mg/l) as Zn | Drinking Water Standard |

EVALUATION OF WASTE DISPOSAL PRACTICES:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Landfill | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Since landfill provides a convenient and adequate method of disposal for these materials they are not considered to be candidates for disposal at National Disposal Sites.

# AMIDES

CHEMICAL FORMULA: The general formula for amides is $R - \overset{O}{\overset{\|}{C}} - NH_2$ where R is an alkyl or aryl group.

GENERAL DESCRIPTION: Neutral compounds which are closely related to the organic acids.

TOXICOLOGY: Most of the saturated amides have low toxicity. The unsaturated and N-substituted amides are frequently irritants and may be absorbed through the skin. In animal experiments, the unsaturated and N-substituted amides have caused injury to the liver kidney and brain.

# AMMONIA, AMMONIUM HYDROXIDE

Ammonium hydroxide is essentially ammonia dissolved in water. This report will cover ammonium hydroxide.

CHEMICAL FORMULA: $NH_4OH$

GENERAL DESCRIPTION: Colorless liquid. Also called aqua ammonia, water of ammonia, aqua ammonium, ammonium hydrate.
Molecular Wt.: 35.05 Melting Pt.: -77°C Boiling Pt.: ________
Density: (Liquid) ________ (Gas) ________
Vapor Pressure: ________
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Wt%): Lower ________ Upper ________
Solubility:
Hot Water: ________ Cold Water: Soluble Ethanol: ________
Other: ________
DOT Classification: ________
Coast Guard Classification: ________
MCA Warning Label

MANUFACTURE: Ammonia is produced in large tonnage by the Haber process in which hydrogen and nitrogen gases react catalytically under elevated temperatures and pressure.

USES: The weaker solution (10%) is used as a reflex stimulant

The stronger solution (28-29%) may be used for the following purposes:

(1) as a detergent and in removing stains, bleaching, calico printing and extracting plant colors and lakaloids.
(2) in the manufacture of ammonium salts and aniline dyes.
(3) as a chemical reagent and in a variety of other uses.

TOXICOLOGY: Irritating to the eyes and mucous membranes.

Corneal ulcers may be caused by the splashing of ammonia water in the eye. Emits toxic fumes upon heating. Edema of the respiratory tract, spasm of the glottis, and asphyxia result from inhalation of concentrated fumes.

The Threshold Limit Value (TLV) is 35 mg/M$^3$($NH_3$)

The Lethal Dose (LD) is 350 mg($NH_3$)/Kg rat.

The Booz-Allen Ratings for ammonia are:

|  | HUMAN |  |  | ECOLOGICAL |  |  | EXPLOSION |  |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 2 | 1 | 2 | 0 | 3 | 0 | 2 | 1 | 2 |

OTHER HAZARDS : No other hazards known.

HANDLING, STORAGE, TRANSPORTATION: Contact with the skin and inhalation of the fume should be avoided. Ammonia should be kept tightly closed.

DISPOSAL/REUSE: For the safe disposal of ammonia into the environment, the following Provisional Limits are recommended:

| Contaminant in Air | Maximum Exposure Limit | Basis for Recommendation |
|---|---|---|
| Ammonium Hydroxide | 0.2 mg/M3 as $NH_3$ | 0.01 TLV for NaOH |

| Contaminant in Water and Soil | Provisional Limit | Basis For Recommendation |
|---|---|---|
| Ammonium Hydroxide | 0.01 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES

| METHOD OF DISPOSAL | EVALUATION |
|---|---|
| Neutralize to ammonium nitrate with nitric acid and use as a fertilizer | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES:

Ammonium hydroxide as a waste stream constituent is not considered to be a candidate for disposal at a National Disposal Site.

## AMMONIUM CHLORIDE, AMMONIUM NITRATE, SODIUM CARBONATE, SODIUM NITRATE

## AMMONIUM CHLORIDE

CHEMICAL FORMULA: $NH_4Cl$

GENERAL DESCRIPTION: White crystaline solid. Also called sal ammoniac.
Molecular Wt.: 53.50 Melting Pt.: Boiling Pt.: 350°C
Density: (Solid) 1.54 g/cc (Gas) (sublimes)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Vol%): Lower Upper
Solubility:
Hot Water: 29.7 g/100 ml @ 0°C Cold Water: 75.8 g/100 ml @ 100°C
Ethanol: Slightly soluble Other: Soluble in $NH_4OH$
DOT Classification:
Coast Guard Classification:

MANUFACTURE: The commercial grade is usually produced by the Solvay Ammonia-Soda process. It is also made by reacting ammonium sulfate with sodium chloride.

USES: In soldering flux, washing powders, pickling agents for zinc coating and tinning, electroplating and medicine and in the manufacture of dyes, various ammonia compounds, fertilizer and cement for pipe joints.

## AMMONIUM NITRATE

CHEMICAL FORMULA: $NH_4NO_3$

GENERAL DESCRIPTION: Colorless crystalline material. Also called Norway Saltpeter.
Molecular Wt.: 80.05 Melting Pt.: 169.6°C Boiling Pt.: 210°C
Density: (Solid) 1.725 g/cc @ 23°C (Gas) (decomposes)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Vol%): Lower Upper
Solubility:
Hot Water: 871g/100g @ 100°C Cold Water: 118g/100g@20°C Ethanol: 3.8g/100g@20°C
Other: Soluble in alkaline
DOT Classification: Oxidizing material, yellow label
Coast Guard Classification: Oxidizing material, yellow label

MANUFACTURE: There are four basic processes for the manufacture of ammonium nitrate: Prilling or spraying, the Stengel process, crystallization and graining. All ammonium nitrate is made by neutralizing nitric acid with ammonia.

USES: Important as a nitrogen fertilizer. In the manufacture of many explosives, and nitrous oxide, an anesthetic.

## SODIUM CARBONATE

CHEMICAL FORMULA: $Na_2CO_3$

GENERAL DESCRIPTION: White, hygroscopic crystalline powder. Also called soda ash.
Molecular Wt.: 106.00 Melting Pt.: 851°C Boiling Pt.: decomposes
Density: (Solid) 2.509 g/cc @ 0°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Vol%): Lower Upper
Solubility:
Hot Water: 45.5 g/100 ml @ 100°C Cold Water: 7.1 g/100 ml @ 0°C
Other: Ethanol: Insoluble
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Over 90% of the worlds soda-ash is made by the Solvay Ammonia Soda process. The rest is recovered from natural deposits or brines. The raw materials for the Solvay process are coke, salt, lime and ammonia.

USES: By the glass, soap, water treatment, chemical, pulp and paper, petroleum, nonferrous metals and textile industries.

## SODIUM NITRATE

CHEMICAL FORMULA: $NaNO_3$

GENERAL DESCRIPTION: Colorless, transparent, odorless, crystalline solid. Also called Chile Saltpeter, soda niter, nitratine.
Molecular Wt.: 85.01 Melting Pt.: 308°C Boiling Pt.: decomposes
Density: (Solid) 2.267 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Vol%): Lower Upper
Solubility:
Hot Water: 180 g/100 ml @ 100°C Cold Water: 73 g/100 ml @ 0°C
Ethanol: Slightly Soluble Other: Glycerol Soluble
DOT Classification: Oxidizing Material
Coast Guard Classification: Oxidizing Material

MANUFACTURE: By reacting sodium carbonate with nitric acid or by recrystallization of Chile Saltpeter, which is impure sodium nitrate.

USES: In fertilizers and in explosives.

TOXICOLOGY: These materials are not particularly toxic. Soda ash, because of its alkalinity is irritating to the skin and respiratory tract. Threshold Limit Values have not been established for these materials. The lethal doses are:

| Contaminant | Lethal Dose |
|---|---|
| Ammonium Chloride | im $LD_{50}$: 30 mg/kg, rat |
| Ammonium Nitrate | --- ---------- |
| Sodium Carbonate | or $LD_{50}$:4200 mg/kg, rat |
| Sodium Nitrate | ip $LD_{50}$:326 mg/kg, rat |

The Booz-Allen Ratings are:

| Contaminant | HUMAN | | | ECOLOGICAL | | | AESTHETIC | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Ammonium Chloride | 1 | 1 | 1 | 2 | 2 | 0 | 2 | 1 | 1 |
| Ammonium Nitrate | 1 | 1 | 1 | 0 | 2 | 0 | 2 | 1 | 3 |
| Sodium Carbonate | 2 | 2 | 2 | 1 | 3 | 1 | 1 | 1 | 1 |
| Sodium Nitrate | 2 | 2 | 1 | 3 | 1 | 0 | 2 | 1 | 2 |

OTHER HAZARDS: Ammonium and sodium nitrate are fire hazards when in contact with organic materials or other readily oxidizable substances. Ammonium nitrate may explode under confinement at high temperature. A mixture of diesel oil and ammonium nitrate is used industrially as an explosive. Upon heating, ammonium nitrate and sodium nitrate give off toxic fumes of nitrogen oxides.

HANDLING, STORAGE, TRANSPORTATION: Store in a dry place protect from moisture, keep ammonium and sodium nitrate away from reducing agents. Sodium carbonate is alkaline and in water will attack aluminum.

DISPOSAL/REUSE: Industrially contaminated materials may on occasion be reprocessed for reuse. If disposal is to be carried out, the following recommended provisional limits should be considered:

| Contaminant in Air | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Ammonium Chloride | 0.10 mg/M$^3$ | 0.01 TLV |
| Ammonium Nitrate | 0.05 mg/M$^3$ | Data for similar compounds |
| Sodium Carbonate | 0.02 mg/M$^3$ | Data for similar compounds |
| Sodium Nitrate | 0.05 mg/M$^3$ | Data for similar compounds |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Ammonium Chloride | 250 mg/l as Cl | Drinking Water Standard |
| Ammonium Nitrate | 45 mg/l as $NO_3$ | Drinking Water Standard |
| Sodium Carbonate | 0.1 mg/l | Stokinger and Woodward Method |
| Sodium Nitrate | 45 mg/l as $NO_3$ | Drinking Water Standard |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Dilute to provisional limits and discharge into sewers or natural streams | Satisfactory |
| Treat ammonium nitrate and ammonium chloride with NaOH to liberate ammonia and soluble salts. Recover the ammonia and dilute the salts to the Provisional Limits then discharge the salts into streams or sewers | Satisfactory |
| Incineration after water dilution. Use gas cleaning devices for the effluent gases. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: The materials discussed in this report have been classified as probable waste stream constituents for municipal disposal and are not considered candidates for disposal at National Disposal Sites.

# HEXAVALENT CHROMIUM COMPOUNDS
# (AMMONIUM CHROMATE, AMMONIUM DICHROMATE, POTASSIUM CHROMATE, POTASSIUM DICHROMATE, SODIUM DICHROMATE, SODIUM CHROMATE)

## AMMONIUM CHROMATE

CHEMICAL FORMULA: $(NH_4)_2 CrO_4$

GENERAL DESCRIPTION: Yellow crystalline solid. Aqueous solution is alkaline.
Molecular Wt.: 152.09 Melting Pt.: d Boiling Pt.:
Density: (Solid) 1.91 g/cc @ 12°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: d Cold Water: 40.5 g/100 cc @ 30°C
Ethanol: Insoluble Other: Slightly soluble in $NH_3$
DOT Classification: Flammable Solid, yellow label
Coast Guard Classification: Flammable solid yellow label.

MANUFACTURE: Sodium chromate is combined with ammonium sulfate.

## AMMONIUM DICHROMATE

CHEMICAL FORMULA: $(NH_4)_2 Cr_2 O_7$

GENERAL DESCRIPTION: Orange crystalline solid. Aqueous solution is acid.
Molecular Wt.: 252.10 Melting Pt.: d Boiling Pt.:
Density: (Solid) 2.15 g/cc @ 25°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 89 g/100 cc @ 30°C Cold Water: 30.8 g/100 cc @ 15°C
Ethanol: Soluble Other:
DOT Classification: Flammable solid, yellow label
Coast Guard Classification:

MANUFACTURE: Sodium dichromate is combined with ammonium sulfate.

## POTASSIUM CHROMATE

CHEMICAL FORMULA: $K_2 Cr O_4$

GENERAL DESCRIPTION: Yellow crystalline solid. Aqueous solution is alkaline.
Molecular Wt.: 194.20 Melting Pt.: 968.3°C Boiling Pt.: ______
Density: (Solid) 2.732 g/cc @ 20°C (Gas) ______
Vapor Pressure: ______
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: 79.2 g/100 cc 100°C Cold Water: 62.9 g/100 cc @ 20°C
Ethanol: Insoluble Other: ______
DOT Classification: ______
Coast Guard Classification: ______

MANUFACTURE: Reacting potassium chloride and sodium chromate, or roasting the ore with potassium carbonate.

## POTASSIUM DICHROMATE

CHEMICAL FORMULA: $K_2Cr_2O_7$

GENERAL DESCRIPTION: Red crystalline solid. Aqueous solution is acid.
Molecular Wt.: 294.19 Melting Pt.: 398°C Boiling Pt.: d 500°C
Density: (Solid) 2.69 g/cc @ 25°C (Gas) ______
Vapor Pressure: ______
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: 102 g/100 cc @ 100°C Cold Water: 4.9 g/100 cc @ 0°C
Ethanol: Insoluble Other: ______
DOT Classification: ______
Coast Guard Classification: ______

MANUFACTURE: Potassium dichromate can be produced by chrome ore roasting with potassium carbonate. Reacting potassium chloride and sodium chromate is a preferred method.

## SODIUM CHROMATE

CHEMICAL FORMULA: $Na_2CrO_4$

GENERAL DESCRIPTION: Yellow crystalline solid.
Molecular Wt.: 162 Melting Pt.: ______ Boiling Pt.: ______
Density: (Solid) 2.710 - 2.736 g/cc (Gas) ______
Vapor Pressure: ______
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: ______ Cold Water: 87.3 g/100 cc @ 30°C

Ethanol: Slightly soluble Other: Soluble in ethyl alcohol
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Roasting chrome ore with soda ash and/or lime.

## SODIUM DICHROMATE

CHEMICAL FORMULA: $Na_2Cr_2O_7$

GENERAL DESCRIPTION: Red crystalline solid anh. 356.7°C M.P.
Molecular Wt.: 298.1 Melting Pt.: $-2H_2O$ 100°C Boiling Pt.: 400°C
Density: (Solid) 2.52 g/cc @ 13°C (Gas) (Decomposes)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 508 g/100 cc @ 80°C Cold Water: 238 g/100 cc @ 0°C
Ethanol: Insoluble Other:
DOT Classification:
Coast Guard Classification:
IATA Classification: Class A, No label, no limit
MCA Requires warning label

MANUFACTURE: Roasting chrome ore with soda ash and/or lime. The resulting sodium chromate is processed further to yield the dichromate.

USES: The distribution of $Na_2Cr_2O_7$ used in 1968 was: Pigments 40%, leather tanning 18%, chromic acid (plating) 17%, metal treatment 10%, textiles and dyes 6%, export and other 9%. The estimate for use made in 1968 for 1972 was 145,000 tons.

SOURCES AND TYPES OF CHROMATE WASTE: All of the industries mentioned above with the possible exception of the pigment industry. Almost all cooling towers. About 32,000 tons of chromium waste, calculated as chromic acid, from the metal finishing industry; most of this is reduced to $Cr^{+3}$. See Table 17.

TOXICOLOGY: Very corrosive when in contact with skin or mucous membranes. Produce ulcerous lesions which heal slowly. Have been associated with lung cancer. The TLV for hexavalent chromates is 0.1 mg/$M^3$ in air while that for chromate ions is 0.5 mg/$M^3$ in air. Very toxic to marine and plant life.

The Booz-Allen Ratings for these compounds are:

Table 17. TYPICAL METAL FINISHING WASTE STREAMS CONTAINING CHROMIUM

| Waste Description | Form | Source: Industry/Process |
|---|---|---|
| 3000 ppm of a mixture of chromium, 20% aluminum sulfate and 15% sulfuric acid (traces of copper, nickel, lead) | Liquid | Aluminum anodizing bath with drag out |
| 12.5% chromic acid - dichromates in 10% to 30% sulfuric acid with 5000 to 120,000 ppm chromium (85% as $Cr^{+3}$) with 100-1000 ppm lead, copper and iron. | Liquid | Metal finishing |
| Dilute chromic acid solution containing chromium +3 at 100-200 ppm and chromium +6 at 2000 to 4000 ppm with traces of organics (combined wash waters). | Liquid | Metal plating |
| Partially neutralized aqueous plating waste containing 5-10% zinc chromate, and 5-10% zinc phosphate contaminated with various organic oils. | Liquid | Zinc plating |
| Solutions of chromates and dichromates in sulfuric acid (6-12%) containing 5000-170,000 ppm chromium with copper lead and traces of organics. | Liquid | Formation of protective and decorative coatings (metal) |
| 0.1-0.5% chromium, 100-400 ppm copper, 100-400 ppm nickel in 5-10% aqueous hydrofluoric-hydrochloric acid. | Liquid | Plating preparation (metal) |
| 1 to 20% chromium in solids concentrations of 10-80% from settling and/or dewatering processes. Includes copper in varying amounts with varying amounts of inert filter aids. | Sludge | Chemical process (plating operation, manufacturing metallurgical) |
| 100-1000 ppm chromium as alkaline cyanide solution (6-20%) with copper in varying amounts with possible traces of organics, nickel, lead and zinc. | Liquid | Metal plating (formation of protective and decorative coatings) |

Table 17. TYPICAL METAL FINISHING WASTE STREAMS CONTAINING CHROMIUM (cont'd.)

| Waste Description | Form | Source: Industry/Process |
|---|---|---|
| 5-6% Chromic acid in water solution with 3% iron | Liquid | (1) Metal plating<br>(2) Ship building |
| 9% chromic acid in water solution with 3% iron | Liquid | Metal finishing and plating |
| 0.1-3% sodium or potassium dichromate in water, usually sulfuric acid present in a 1-25% concentration. | Liquid | (1) Metal Finishing<br>(2) Shipbuilding<br>(3) Plating |

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Ammonium Chromate | 3 | 3 | 3 | U | 2 | U | 2 | 1 | 2 |
| Ammonium Dichromate | 3 | 2 | 3 | 2 | 2 | U | 2 | 1 | 2 |
| Potassium Chromate | 3 | 3 | 3 | 3 | 3 | 3 | 1 | 1 | 1 |
| Potassium Dichromate | 3 | 3 | 3 | U | 3 | 3 | 1 | 1 | 1 |
| Sodium Chromate | 3 | 3 | 3 | 3 | 4 | U | 1 | 1 | 1 |
| Sodium Dichromate | 3 | 3 | 3 | U | 3 | U | 1 | 1 | 1 |

OTHER HAZARDS: Powerful oxidizing agents and should not be mixed with reducing agents or organic materials. Concentrated aqueous solutions will attack metals at high temperatures.

HANDLING, STORAGE, TRANSPORTATION: Avoid storing at high temperature. Avoid contact with reducing agents. Avoid creation of dust during handling, transfer and storage. Workers must be protected against contact of these materials with eyes, skin and internal organs. DOT classifies ammonium chromate and dichromate as flammable solids which require yellow labels.

DISPOSAL/REUSE: Discharge into open water ways is severly restricted. U.S. Public Health Service recommends 0.05 ppm as upper limit for potable water. Discharge of $Cr^{6+}$ into municipal sewage is normally set at near 5 ppm. For safe disposal of chromates, the following Provisional Limits for release into the environment are recommended:

| Contaminant in Air | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Ammonium Chromate | 0.001 mg/M$^3$ as $CrO_3$ | 0.01 TLV |
| Ammonium Dichromate | 0.001 mg/M$^3$ as $CrO_3$ | 0.01 TLV |
| Potassium Chromate | 0.001 mg/M$^3$ as $CrO_3$ | 0.01 TLV |
| Potassium Dichromate | 0.001 mg/M$^3$ as $CrO_3$ | 0.01 TLV |
| Sodium Chromate | 0.001 mg/M$^3$ as $CrO_3$ | 0.01 TLV |
| Sodium Dichromate | 0.001 mg/M$^3$ as $CrO_3$ | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Ammonium Chromate | 0.05 ppm (mg/l) as Cr | Drinking Water Standard |
| Ammonium Dichromate | 0.05 ppm (mg/l) as Cr | Drinking Water Standard |
| Potassium Chromate | 0.05 ppm (mg/l) as Cr | Drinking Water Standard |
| Potassium Dichromate | 0.05 ppm (mg/l) as Cr | Drinking Water Standard |
| Sodium Chromate | 0.05 ppm (mg/l) as Cr | Drinking Water Standard |
| Sodium Dichromate | 0.05 ppm (mg/l) as Cr | Drinking Water Standard |

Reclamation of chromium from waste sludges is seldom practical.

| EVALUATION OF WASTE MANAGEMENT PRACTICES: | EVALUATION |
|---|---|
| Reduction and precipitation as hydroxides, with disposal of sludges in either approved landfills or by incineration. Ion exchange electro chemical reduction. | Satisfactory |
| Direct precipitation by use of barium or lead salts | Not satisfactory due to potential handling problems due to poisonous heavy metals. |
| Ion flotation, electrodialysis, activated-carbon absorption, liquid-liquid extraction, activated carbon reduction, and reverse osmosis | Promising method in various stages of development |

APPLICABILITY TO NATIONAL DISPOSAL SITES: The chromates discussed here are considered as candidate waste stream constituents for National Disposal Sites.

## AMMONIUM THIOCYANATE

CHEMICAL FORMULA: $NH_4SCN$

GENERAL DESCRIPTION: Colorless solid. Also called ammonium sulfocyanate
Molecular Wt.: 76.1 Melting Pt.: 149.6°C Boiling Pt.: 170°C
Density: (Solid) 1.305 g/cc (Gas) decomposes
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water:
Ethanol: Other:
DOT Classification:
Coast Guard Classification:

TOXICOLOGY: Prolonged absorption may produce various skin eruptions, running nose, and occasionally dizziness, cramps, nausea, vomiting and mild or severe disturbances of the nervous system. Thiocyanates have a low acute toxicity.

The Booz-Allen Ratings for thiocyanates are:

| | HUMAN | | | BIOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 1 | 1 | 2 | 0 | 0 | 0 | 2 | 1 | 1 |

OTHER HAZARDS: Dangerous. Thiocyanites emit highly toxic fumes of cyanides when heated to decomposition or on contact with acid or acid fumes.

HANDLING, STORAGE, TRANSPORTATION: Store in a cool, dry, well ventilated area, away from heat or open flames.

## ANILINE

CHEMICAL FORMULA: $C_6H_5NH_2$,

GENERAL DESCRIPTION: Colorless oily liquid. Also called phenylamine, aminobenzene.

Molecular Wt.: 93.12 Melting Pt.: 6.2°C Boiling Pt.: 184.4°C
Density: (Liquid) 1.02 @ 20°C (Gas) 3.22 g/l
Vapor Pressure: 1 mm @ 35°C 10 mm @ 70°C
Flash Pt.: 168°F Autoignition Temperature: 617°C
Explosive Limits in Air (Wt%): Lower ? Upper ?
Solubility:
Hot Water: 6.4 g/100 ml Cold Water: 3.5g/100 ml Ethanol: soluble
Other: Benzene, miscible in chloroform
DOT Classification:
Coast Guard Classification:

MANUFACTURE: By the reduction of nitrobenzene or by the amination of chlorobenzene. Total U.S. production of analine for 1970 was 398,362,000#.

MANUFACTURERS OF ANILINE ARE:

Allied Chemical Corporation
American Cyanamid Company
E.I. duPont de Nemours & Company, Incorporated
First Chemical Corporation
Mobay Chemical Company
Rubicon Chemicals, Incorporated
Uniroyal, Incorporated

USES: In the manufacture of dyes, rubber chemicals, sulfa drugs and synthetic sweetening agents.

TOXICOLOGY: Highly toxic. May enter the body through the lungs, the gastro intestinal tract or skin. Long and continued exposure to even small amounts may produce tumors and cancer of the bladder. May produce anoxemia and depression of the central nervous system. Acute exposures produce methemoglobinaemia and anoxemia. Less acute exposure over weeks or months produce hemolysis of the red blood cells followed by stimulation of the bone marrow and attempts at regeneration. The liver may be affected with the production of jaundice.

The Threshold Limit value for aniline is: 5 ppm (19 mg/M³).

The Booz-Allen Ratings for aniline are:

| HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 1 | 2 | 0 | 2 | 1 | 2 |

OTHER HAZARDS: Some fire hazard.

HANDLING, STORAGE, TRANSPORTATION: Should be handled in a way to prevent contact. Keep containers closed and prevent leakage. Store in a cool, well-ventilated area away from fire hazards.

DISPOSAL/REUSE: Contaminated or degraded materials which cannot be recycled must be disposed of in a safe manner. The following are Recommended Provisional Limits for release into the environment:

| | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Contaminant in Air | 0.05 ppm (.019 mg/M$^3$) | 0.01 TLV |
| Contaminant in Soil and Water | 0.95 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

All possible waste aniline should be recycled.

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Incineration with oxides of nitrogen removed from effluent gases by scrubber, catalytic and/or thermal devices | Recommended |
| Activated sludge treatment | Satisfactory |
| Activated carbon treatment | Satisfactory |

APPLICABILITY TO NATIONAL SITES: Aniline is satisfactorily treated at industrial sites and is not considered a candidate for National Disposal Site Treatment.

## ARSENIC TRIOXIDE

CHEMICAL FORMULA: $As_2O_3$

GENERAL DESCRIPTION: Highly toxic colorless crystal. Also called white arsenic

Molecular Wt.: 197.82°C Melting Pt.: Sublimes 193°C Boiling Pt.: 457.2°C
Density: (Solid) 3.738 g/cc (Gas) ____
Vapor Pressure: 1 mm @ 212°C, 10 mm @ 259.7°C, 100 mm @ 332.5°C
Flash Pt.: None ____ Autoignition Temperature: ____
Explosive Limits in Air (wt%): Lower None ____ Upper ____
Solubility:
    Hot Water: 11.46 g/100 cc @ 100°C Cold Water: 2.04 g/100 cc @ 25°C
    Ethanol: Soluble ____ Other: Alkal. and HCl
DOT Classification: Poisonous solid, Class B
Coast Guard Classification: ____

MANUFACTURE: Occurs in nature as ores containing various arsenic compounds. The ores are not mined and processed for the arsenic, but arsenic is a major by-product of the copper, lead, zinc and gold smelting industries. American Smelting and Refining Company produced 14,000 tons (12,700,000kg) of arsenic trioxide in 1970.

USES: The major use of arsenic trioxide is in the production of agricultural pesticides. These are used in cattle and sheep dip solutions, applied to foliage or to the ground and for wood perservatives. Arsenic trioxide is also used in the glass industry.

TOXICOLOGY: Arsenic trioxide is a powerful poison. The systemic effects are usually caused by ingestion. As little as 0.1 gram ingested can be fatal. It can also be absorbed by inhalation of the dust. Skin contact can cause dermititis, but normally will not cause systemic symptoms. The acute poisoning symptoms include difficulty in swallowing, severe abdominal pain, vomiting, diarrhea, pain in the limbs, muscle cramps, cold damp skin, rapid weak pulse, shock, unconsciousness, convulsions, and death. The symptoms of chronic low level arsenic exposure are difficult to diagnose due to the wide variety of unpredictable symptoms which may arise.

Arsenic trioxide is highly toxic to most forms of animal life. Adverse effects on vegetation have been observed in areas downwind from where arsenic trioxide trash has been burned, but detailed information on plant effects is not available.

The Booz-Allen Ratings for arsenic trioxide are:

| HUMAN | | | ECOLOGICAL | | | AESTHETIC | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 2 | 3 | 3 | 3 | 3 | 1 | 2 |

OTHER HAZARDS: Arsenic trioxide is noncombustible, nonexplosive and as a dry solid is noncorrosive to steel. It should be considered a hazard if heated, since it sublimes at 193°C.

HANDLING, STORAGE, TRANSPORTATION: Because of its highly toxic nature, special care must be taken to prevent contact with personnel in the storage, handling, transportation and disposal of arsenic trioxide. Arsenic trioxide should be stored away from food products and combustible materials. It should be stored in containers which are siftproof. Spills should be cleaned up immediately in such a way so as not to generate dust. It should be shipped in steel drums or tight wooden drums. Steel hoppers or bottom outlet, siftproof, self clearing railcars equipped with weatherproof covers are also used.

DISPOSAL/REUSE: American Smelting and Refining is accepting crude $As_2O_3$ from the smelting industry on a broad scale. Flue dust from other smelters is sent to ASARCO for residual metals recovery and $As_2O_3$ purification. For release of arsenic trioxide to the environment the following Provisional Limits are recommended:

| Arsenic Trioxide as a Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.005 mg/M$^3$ as As | 0.01 TLV for As |
| Water and Soil | 0.05 ppm (mg/l) as As | Drinking Water Standard |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Recycling/reprocessing. Acceptance of flue dust from other smelters by American Smelting and Refining Co. | Most satisfactory |
| Land burial | Satisfactory, but expensive and $As_2O_3$ is lost. |
| Long term storage | Satisfactory |
| Abatement in Flue Streams | |
| Multistage electrostatic Precipitators | Less than adequate |
| Filter/bag house | Adequate but expensive |
| TRW charged droplet scrubber | Adequate |
| Wet vacuum filtering | Very little information, but reported to be 100% effective |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Arsenic trioxide is considered as a candidate for National Disposal Sites for the following reasons: (1) It is highly toxic and nondegradable; (2) $As_2O_3$ waste is present in large quantities; (3) $As_2O_3$ waste is widely distributed and comes from a large number of industries; and (4) the feasibility of a centrally located facility has already been shown by the treatment of flue dust from other smelters at ASARCO in Tacoma, Washington.

# BENZOIC ACID

CHEMICAL FORMULA: $C_6H_5CO_2H$.

GENERAL DESCRIPTION: White crystalline solid. IUC Name: Benzene carboxylic acid. Also called phenylformic acid.

Molecular Wt.: 122.12 Melting Pt.: 121.7°C Boiling Pt.: 249°C
Density: (Solid) 1.316 g/cc (Gas) 4.21 g/l
Vapor Pressure: 1 mm @ 96.0°C
Flash Pt.: 250° F (C.C.) Autoignition Temperature: 1065° F
Explosive Limits in Air (Wt%): Lower ____ Upper ____
Solubility:
Cold Water: 0.18 g/100 ml @ 4°C Hot Water 2.2 g/100 ml @ 75°C
Ethanol: Soluble Other: Ether, acetone
DOT Classification: ____
Coast Guard Classification: ____

MANUFACTURE: By catalytic oxidation of toluene.

USES: As a food additive (41%), as a plasticizer (36%) in alkyd resins (10%) and in pharmaceuticals, flavorings and miscellaneous uses (10%).

TOXICOLOGY: Low toxicity. It can be ingested.

The Booz-Allen Ratings for benzoic acid are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 1 | 1 | 1 | 1 | 2 | 0 | 1 | 1 | 1 |

OTHER HAZARDS: Slight fire hazard when exposed to heat or flame; it can react with oxidizing materials.

HANDLING, STORAGE, TRANSPORTATION: No special handling requirement. It should be stored in a cool place, away from oxidizing materials.

DISPOSAL/REUSE: Most benzoic acid is used in such a way that it is not recoverable. Dilute waste streams may be treated on site or discharged into the municipal sewer after pH adjustment.

Recommended Provisional Limits for disposal of benzoic acid are:

| Benzoic acid in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.25 mg/M$^3$ | Based on Similar Compounds |
| Water and Soil | 1.25 mg/l | Based on Similar Compounds |

EVALUATION OF WASTE MANAGEMENT:

PRACTICES:

As much material as possible is recycled. This is the best method of handling contaminated material.

| METHODS OF DISPOSAL | EVALUATION |
|---|---|
| Discharge into sewer after pH adjustment to 6.0 to 9.0 for treatment in the municipal sewage plant | Satisfactory |
| Incineration | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Benzoic acid waste can be treated by industrial or municipal disposal methods and is not considered to be a candidate for National Disposal Sites.

# BORON

CHEMICAL FORMULA: B

GENERAL DESCRIPTION: Crystals or yellow or brown amorphous powder.

Atomic Wt.: 10.82 Melting Pt.: 2300°C Boiling Pt.: 2550°C
Density (Solid): 2.33 g/cc @ 20°C

TOXICOLOGY: Boron compounds are not highly toxic and are not considered industrial poisons. Boron affects the central nervous system. Boron poisoning causes depression of the circulation, persistent vomiting and diarrhea followed by profound shock and coma. The temperature is subnormal and the body may be covered by a scarlatina-form rash. Poisoning can be caused by absorbtion from ointments applied to burned areas or wounds. It is not absorbed through intact skin.

OTHER HAZARDS: Boron is a moderate fire hazard in the form of dust when exposed to air or by reaction with oxidizing materials. It is also an explosion hazard in the form of dust.

# BORON CHLORIDE

CHEMICAL FORMULA: $BCl_3$

GENERAL DESCRIPTION: Colorless fuming liquid. Also called boron trichloride.
Molecular Wt.: 117.17 Melting Pt.: -107.3°C Boiling Pt.: 12.5°C
Density: (Liquid) 1.349 g/cc @ 11°C (Gas) 4.03 g/l
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: decomposes Cold Water: Ethanol: decomposes
Other:
DOT Classification:
Coast Guard Classification:

MANUFACTURE: By chlorination of a mixture of boron trioxide and carbon at a temperature range of from 1600 to 1800°F. Also by the following reactions:

$$(1)\quad 7\,B_2O_3 + NaCl \xrightarrow{800-1000°C} 2\,BCl_3 + Na_2B_4O_7$$

$$(2)\quad 2\,NaBF_4 + 3\,MgCl_2 \xrightarrow{500-1000°C} 2\,BCl_3 + NaF + 3\,MgF_2$$

$$(3)\quad 2\,B_2O_3 + 3\,SiCl_4 \xrightarrow{600-1000°C} 4\,BCl_3 + 3SiO_2$$

USES: In the manufacture of boron compounds, as an acidic catalyst for organic reactions, in the purification of aluminum, magnesium, zinc and copper alloys and to remove nitrides, carbides and oxides.

TOXICOLOGY: The toxic effect of boron chloride is not too well known. However, when heated to decomposition, it will emit toxic fumes of chlorides. The reported lethal Concentration is "ih $LC_{50}$: 20 ppm rat".

The Booz-Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 2 | 2 | 2 | 2 | U | U | 2 | 2 | 2 |

OTHER HAZARDS: Boron chloride hydrolyzes readily in moist air or water to yield corrosive hydrochloric acid.

HANDLING, STORAGE, TRANSPORTATION: Contact with skin and inhalation of fumes should be avoided. It should be kept away from food. The container should be kept tightly closed.

DISPOSAL/REUSE: Boron chloride probably could not be economically reprocess-

and for reuse when it is contaminated or present in a waste stream. For its safe disposal the following Provisional Limits should be considered before releasing it into the environment:

| $BCl_3$ as a Contaminant in Air | Maximum Exposure Limit | Basis for Recommendation |
|---|---|---|
| | 0.03 mg/M$^3$ | 0.01 TLV for $BF_3$ |

| $BCl_3$ as a Contaminant in Soil and Water | Provisional Limit | Basis for Recommendation |
|---|---|---|
| | 0.15 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Neutralization with soda ash-slaked lime solution. The neutral solution of sodium or calcium chloride and borate are formed and can be discharged to streams. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Boron chloride as a waste stream constituent can be adequately disposed of in the industrial sites by conventional means and is not considered to be a candidate for disposal at National Disposal Sites.

## BUTYL DISULFIDE

CHEMICAL FORMULA: $CH_3(CH_2)_3S\ S(CH_2)_3CH_3$

GENERAL DESCRIPTION: Colorless liquid. IUC Name: 1-(butyldithio)butane.
Molecular Wt.: 178.4 Melting Pt.: ________ Boiling Pt.: 101°C @ 15 /mm Hg
Density: (Liquid) ________ (Gas) ________
Vapor Pressure: ________
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Wt%): Lower ________ Upper ________
Solubility:
    Hot Water: Insoluble Cold Water: ________ Ethanol: Infinitely /soluble
    Other: Infinitely soluble in ether
DOT Classification: ________
Coast Guard Classification: ________

TOXICOLOGY: Animal experiments suggest that alkyl disulfides are dangerous and may cause hemolytic anemia. They may also produce allergic dermatitis.

OTHER HAZARDS: Dangerous when heated to decomposition, it emits highly toxic fumes of sulfides. It probably reacts strongly with powerful oxidizers. It is probably a moderate fire hazard.

HANDLING, STORAGE, TRANSPORTATION: Store in a cool, dry well ventilated area away from heat and open flame. Avoid breathing fumes.

# MERCAPTANS
# (BUTYL MERCAPTAN, ETHYL MERCAPTAN, METHYL MERCAPTAN)

## BUTYL MERCAPTAN

There are three isomers

### n - BUTYL MERCAPTAN

CHEMICAL FORMULA: $CH_3(CH_2)_2CH_2SH$

GENERAL DESCRIPTION: Colorless liquid, skunk-like odor. IUC Name: 1-Butanethiol. Also called normal butyl thioalcohol and thiobutyl alcohol.
Molecular Wt.: 90.19 Melting Pt.: -115.9°C Boiling Pt.: 98.2°C
Density: (Liquid) 0.8365 g/cc @ 25°C (Gas) 1.1 g/l
Vapor Pressure:
Flash Pt.: 35°F Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Slightly Ethanol: Very solubl
Other: Very soluble in ether, liquid hydrogen sulfide
DOT Classification:
Coast Guard Classification: Flammable liquid

### sec - BUTYL MERCAPTAN

CHEMICAL FORMULA: $CH_3CH_2CH(SH)CH_3$

GENERAL DESCRIPTION: Mobile liquid, skunk-like odor. IUC Name: 2-Butanethiol. Also called sec-butyl thioalcohol
Molecular Wt.: 90.19 Melting Pt.: -165°C Boiling Pt.: 84-85°C
Density: (Liquid) 0.83 @ 17°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: slightly Ethanol: Very
Other: Very soluble in ether, liquid hydrogen sulfide
DOT Classification:
Coast Guard Classification:

## tert - BUTYL MERCAPTAN

CHEMICAL FORMULA: $(CH_3)_3CSH$

GENERAL DESCRIPTION: Liquid, skunk like odor. IUC Name: 2-Methyl-2-propanethiol.
Molecular Wt.: 90.19 Melting Pt.: -0.5°C Boiling Pt.: 63.7-64.2°C
Density: (Liquid) 0.79-82 g/cc @ 15°C (Gas) 3.1 g/l
Vapor Pressure:
Flash Pt.: -15°F Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Slightly Ethanol: Very
Other: Very soluble in ether, Liquid hydrogen sulfide.
DOT Classification:
Coast Guard Classification:

## ETHYL MERCAPTAN

CHEMICAL FORMULA: $CH_3CH_2SH$

GENERAL DESCRIPTION: Colorless liquid, penetrating garlic-like odor. IUC Name: Ethanethiol. Also called ethyl thioalcohol, ethyl hydrosulfide, ethyl sulfhydrate.
Molecular Wt.: 62.13 Melting Pt.: -121 -148°C Boiling Pt.: 34 - 37°C
Density: (Liquid) 0.83907 g/cc @ 20°C (Gas) 2.14 g/l
Vapor Pressure:
Flash Pt.: <80° F (CC) Autoignition Temperature: 570°F
Explosive Limits in Air (Wt%): Lower 2.8% Upper 18.2%
Solubility:
Hot Water: Cold Water: 67 parts Ethanol: Soluble
Other: Soluble in ether
DOT Classification:
Coast Guard Classification:

## METHYL MERCAPTAN

CHEMICAL FORMULA: $CH_3SH$

GENERAL DESCRIPTION: Liquid or gas. IUC Name: Methanethiol.
Molecular Wt.: 48.10 Melting Pt.: -121°C Boiling Pt.: 7.6°C
Density: (Liquid) 0.868 g/cc @ 20°C (Gas) 1.66 g/l
Vapor Pressure: 43.7 psi @ 100°F; 2 atm @ 26.1°C; 5 atm @ 55.9°C

Flash Pt.: 0°F Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Slightly Cold Water: Freely Ethanol: Very
Other: Very soluble in methanol, very soluble in ether
DOT Classification:
Coast Guard Classification: Flammable gas.

MANUFACTURE: Reaction of hydrogen sulfide with olefins or alcohols. Methyl mercaptan is manufactured by Air Products and Chemical Inc., and Pennwalt Corp. n-Butyl and ethyl mercaptan are manufactured by Pennwalt Corp. and Phillips Petroleum Company.

USES: Ethyl and butyl mercaptan are used as intermediates in the manufacture of various agricultural chemicals. Methyl mercaptan is used in the first step of a commercial synthesis of methionine, an amino acid feed supplement.

TOXICOLOGY: Butyl, ethyl and methyl mercaptan are moderately toxic when ingested, inhaled or come in contact with the skin. n-Butyl mercaptan may cause nausea from its odor and may be narcotic in high concentrations. Ethyl mercaptan may cause nausea, headache and irritability. Methyl mercaptan poisoning is somewhat similar to that of hydrogen sulfide, although less severe.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations for these compounds are:

| MERCAPTAN | TLV | MAC |
|---|---|---|
| Butyl | 0.5 ppm | 10 ppm for 8-hour exposure |
| Ethyl | 0.5 ppm | 250 ppm for 8-hour exposure |
| Methyl | 0.5 ppm | 50 ppm for 8-hour exposure |

The Booz-Allen Ratings for these mercaptans are:

| | HUMAN | | | BIOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Butyl | 2 | 2 | 2 | 1 | U | U | 2 | 1 | 2 |
| Ethyl | 2 | 2 | 2 | U | U | U | 2 | 2 | 2 |
| Methyl | 3 | 3 | 3 | 3 | 3 | U | 3 | 2 | 3 |

OTHER HAZARDS: All of the mercaptans listed in this report are flammable. Ethyl mercaptan has known explosive limits. They emit highly toxic fumes when heated to decomposition.

HANDLING, STORAGE, TRANSPORTATION: Steel, stainless steel and copper-free steel alloys are the preferred materials of construction for mercaptan service. Stainless steel should be used for any vessel or line which is to be open and exposed to air frequently.

Aluminum is also suitable for mercaptan use provided the pressure rating of aluminum equipment or piping is sufficient to meet pressure requirements of the application.

Venting of storage tanks in order to reduce pressure should be to a scrubber to remove the mercaptan. Only hermetically sealed pumps should be used.

Plastic gloves and chemical goggles should be worn to protect the skin and eyes when handling mercaptans. A self-contained breather type mask is recommended for protection when working in areas of high vapor concentration or for prolonged exposure to lower concentrations of vapor.

DISPOSAL/REUSE: When mercaptans are disposed of by release to the environment, the acceptable criteria for releasing $H_2S$ and $SO_2$ must be considered. The Provisional Limits for releasing the mercaptans, $H_2S$ and $SO_2$ are:

| Contaminant in Air | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Butyl Mercaptan | 0.005 ppm (0.01 mg/$M^3$) | 0.01 TLV |
| Ethyl Mercaptan | 0.005 ppm (0.01 mg/$M^3$) | 0.01 TLV |
| Methyl Mercaptan | 0.005 ppm (0.01 mg/$M^3$) | 0.01 TLV |
| $H_2S$ released to air outside plant. | 0.1 ppm | Below odor detection level |
| $H_2S$ released to air inside plant | 10 ppm | TLV for repeated 8-hour exposure |
| $SO_2$ | 200lb/hr of $SO_2$ effluent at a maximum stack concentration of 500 ppm. | Los Angeles Air-Pollution Control District Rule 53.2 |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Butyl Mercaptan | 0.05 ppm (mg/l)/24 hrs | Stokinger and Woodward Method |
| Ethyl Mercaptan | 0.05 ppm (mg/l)/24 hrs | Stokinger and Woodward Method |
| Methyl Mercaptan | 0.075 ppm (mg/l)/24 hrs | Stokinger and Woodward Method |
| $H_2S$ released to water sources | 0.1 mg/l | To avoid fish kill and water taste. |

EVALUATION OF WASTE MANAGEMENT PRACTICES: Recycling of contaminated mercaptans is possible sometimes and this is the best means of liquid waste disposal.

| METHODS OF DISPOSAL | EVALUATION |
|---|---|
| Incineration of both liquid and gaseous waste with a scrubber for the effluent gas. | Satisfactory |
| For small volume gas scrubbing can be used. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Adequate methods for handling mercaptan waste are available and are now being used, therefore, these materials are not considered candidate waste stream constituents for National Disposal Sites.

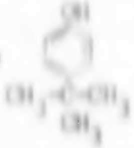
# PHENOLS

(Butyl Phenol, Ethyl Phenol, Carbolic Acid (Phenol), Cresylic Acid (Cresol), Xylenol, Diethylstilbestrol)

## BUTYL PHENOL

The description of one isomer, para-tertiary-butyl phenol, will be given here.

CHEMICAL FORMULA: $C_4H_9C_6H_4OH$,



GENERAL DESCRIPTION: Practically white flakes or crystals. IUC Name 4-t-butylphenol. Also called butylphen and 4-(1,1-dimethylethyl)-phenol.

Molecular Wt.: 150.21 Melting Pt.: 98°C Boiling Pt.: 237°C

Density: (Solid) 0.9081 g/cc @ 114°C (Gas) 5.1 g/l

Vapor Pressure: 1 mm @ 70°C

Flash Pt.: ____ Autoignition Temperature: ____

Explosive Limits in Air (Wt%): Lower ____ Upper ____

Solubility:

Hot Water: ____ Cold Water: Insoluble

Ethanol: Soluble Other: Soluble in ether

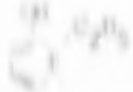
DOT Classification: ____

Coast Guard Classification: ____

## ETHYL PHENOL

The description of one isomer ortho-ethyl-phenol will be given here.

CHEMICAL FORMULA: $C_2H_5C_6H_4OH$,



GENERAL DESCRIPTION: Colorless liquid, phenol odor. Also called phlorol.

Molecular Wt.: 122.17 Melting Pt.: <18°C Boiling Pt.: 207°C

Density: (Liquid) 1.0371 g/cc @ 0°C (Gas) ____

Vapor Pressure: ____

Flash Pt.: ____ Autoignition Temperature: ____

Explosive Limits in Air (Wt%): Lower ____ Upper ____

Solubility:

Hot Water: Slightly Cold Water: Slightly Ethanol: Very Sol.

Other: Soluble in ether, acetone and benzene

DOT Classification: ____

Coast Guard Classification: ____

## PHENOL

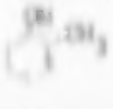
CHEMICAL FORMULA: $C_6H_5OH$

GENERAL DESCRIPTION: White crystalline solid which turns pink or red if not perfectly pure. Burning taste. Distinctive odor. Also called carbolic acid and phenylic acid.

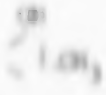
Molecular Wt.: 94.11 Melting Pt.: 40.9°C Boiling Pt.: 181.8°C
Density: (Solid) 1.072 g/cc (Gas)
Vapor Pressure: 1 mm @ 40.1°C
Flash Pt.: 175°F (C.C.) Autoignition Temperature: 1319°F
Explosive Limits in Air (%V): Lower Upper
Solubility:
Hot Water: Cold Water: 1 g/15 ml @ 16°C
Ethanol: Soluble Other: Soluble in chloroform, ether glycerol and carbon disulfide
DOT Classification: Poison B, poison label, 55 gallons
Coast Guard Classification: Poison B
MCA Warning Label
IATA Classification: Poison B, poison label
1 litre (passenger), 220 litres (cargo)

## CRESOL

CHEMICAL FORMULA: $CH_3C_6H_4OH$



ortho-cresol



meta-cresol

para-cresol

GENERAL DESCRIPTION: Colorless or yellowish to brown-yellow or pink liquid. Phenol like odor. Mixture of the cresol isomers. Also called cresylic acid, cresylol, and tricresol.

Molecular Wt.: 108.1 Melting Pt.: 10.9-35.5°C Boiling Pt.: 191-203°C
Density: (Liquid) 1.030-1.038 g/cc @ 25°C (Gas) 3.72 g/l
Vapor Pressure: 1 mm @ 38-53°C
Flash Pt.: 110°F Autoignition Temperature:
Explosive Limits in Air (%V): Lower Upper 1.35% @300°F
Solubility:
Hot Water: Cold Water: 50 parts Ethanol: miscible
Other: Soluble in benzene, ether, glycerol, petroleum ether & alkali
DOT Classification:
Coast Guard Classification: Flammable liquid
MCA Warning Label
IATA Classification: Poison B, poison label
1 litre (passenger), 220 litres (cargo)

## XYLENOL

The description of 3,5-xylenol will be given here. The physical constants are similar and the solubilities are the same for all isomers.

CHEMICAL FORMULA: $(CH_3)_2C_6H_3OH$

GENERAL DESCRIPTION: White crystalline solid. IUC Name: 3,5-dimethylphenol. Also called 1-hydroxy-3,5-dimethylbenzene, and 5-hydroxy-1,3-dimethylbenzene.
Molecular Wt.: 122.16 Melting Pt.: 64°C Boiling Pt.: 219.5°C
Density: (Solid) (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Slightly
Ethanol: Soluble Other: Soluble in chloroform, ether & benzene.
DOT Classification:
Coast Guard Classification:

## DIETHYLSTILBESTROL

CHEMICAL FORMULA: $C_{18}H_{20}O_2$,

GENERAL DESCRIPTION: Crystalline solid. Also called stilbestrol.
Molecular Wt.: 268.34 Melting Pt.: 169-172°C Boiling Pt.:
Density: (Solid) (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Almost insoluble
Ethanol: Soluble Other: Soluble in ether, chloroform, fatty oils, dilute hydroxides.
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Butyl and ethyl phenols are manufactured by alkylation of phenol with the appropriate olefin in the presence of an acid catalyst.

Phenol is manufactured principally by cumene peroxidation and by alkaline hydrolysis of chlorobenzene.

Cresol, which exists as a mixture of three isomers, and xylenol, which exists as six isomers, are derived from coal tar.

Diethylstilbestrol is derived from a variety of methods and starting materials.

USES: Cresol is used in the manufacture of synthetic resins and as a local antiseptic and disinfectant. Xylenol is used the preparation of disinfectants and synthetic resins.

Butyl and ethyl phenols are used as antioxidants and in the manufacture of antioxidants and synthetic resins.

Phenol: About 50% is used in the preparation of phenolic resins. The rest is used in the synthesis of monomers for other resins.

Diethylstilbestrol is used in estrogenic hormone therapy in humans, as an aid to increase weight in cattle, sheep and pigs and as a caponization agent for poultry.

TOXICOLOGY: Phenol, cresol, xylenol and butyl and ethyl phenol principally effect the nervous system causing headache, dizziness and muscular weakness followed, in acute cases, by loss of consciousness, collapse and death. They are corrosive to body tissues. Fatal doses may be absorbed thru the skin.

Diethylstilbestrol is corrosive to body tissue to a lesser degree than the other phenols treated here. When used in hormone therapy is has shown such side effects as gastrointestinal upset, dizziness, menstrual disturbances and headache. Its use has been associated with cell damage. This indicates the inadvisability of its use during pregnancy and lactation. There has been a great deal of concern recently with birth defects possibly caused by ingestion of meat containing trace amounts of diethylstilbestrol used to fatten cattle.

The Booz-Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Butyl Phenol | 1 | 1 | 2 | U | U | U | 2 | 1 | 2 |
| Ethyl Phenol | 1 | 1 | U | U | U | U | 1 | 1 | 2 |
| Cresol | 2 | 2 | 2 | 2 | 3 | U | 2 | 1 | 2 |
| Phenol | 3 | 3 | 2 | 2 | 3 | U | 2 | 1 | 2 |
| Diethylstilbestrol | 2 | 2 | 2 | 1 | U | U | 1 | 1 | 1 |
| Xylenol | 3 | 3 | 3 | 2 | 3 | U | 1 | 1 | 1 |

OTHER HAZARDS: All of these phenols are considered slight fire hazards. Toxic fumes are emitted when heated to decomposition.

**HANDLING, STORAGE, TRANSPORTATION:** The most important considerations in the handling, storage and transportation of these materials are provisions for adequate ventilation in work areas and fire prevention procedures. Wear protective equipment to prevent skin and eye contact.

**DISPOSAL/REUSE:** For disposal of contaminated material the following Provisional Limits are recommended:

| Contaminant in Air | Provisional Limit<br>ppm | <br>mg/M$^3$ | Basis for Recommendation |
|---|---|---|---|
| Phenol (Carbolic Acid) | 0.05 | 0.19 | 0.01 TLV |
| Cresol (Cresylic Acid) | 0.05 | 0.19 | 0.01 TLV |
| Ethyl Phenol | - | 0.19 | Based on similar compounds |
| Butyl Phenol | - | 0.19 | Based on similar compounds |
| Diethylstilbestrol | - | 0.19 | Based on similar compounds |
| Xylenol | - | 0.19 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Phenol (Carbolic Acid) | 0.001 | Drinking Water Standard |
| Cresol (Cresylic Acid) | 0.001 | Drinking Water Standard |
| Ethyl Phenol | 0.001 | Based on similar compounds |
| Butyl Phenol | 0.001 | Based on similar compounds |
| Diethylstilbestrol | 0.001 | Based on similar compounds |
| Xylenol | 0.001 | Based on similar compounds |

**EVALUATION OF WASTE MANAGEMENT PRACTICES:**

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Biological treatment of aqueous wastes | Satisfactory |
| Controlled incineration of organic and aqueous waste | Satisfactory |

**APPLICABILITY TO NATIONAL DISPOSAL SITES:** Wastes containing these materials may be properly disposed of at industrial or municipal facilities. These materials are not considered to be waste stream constituents for National Disposal Sites.

## BUTYRIC ACID

CHEMICAL FORMULA: $CH_3(CH_2)_2\overset{O}{\overset{\|}{C}}-OH$

GENERAL DESCRIPTION: Colorless liquid. IUC Name: Butanoic acid. Also called ethyl acetic acid, propyl formic acid and n-butyric acid
Molecular Wt.: 88.10 Melting Pt.: -7.9° C Boiling Pt.: 163.5°
Density: (Liquid) 0.959 g/cc @ 20° C (Gas)
Vapor Pressure: 0.43 mm @ 20° C
Flash Pt.: 161 ° F Autoignition Temperature: 846°F
Explosive Limits in Air (Wt%): Lower 2.0% Upper 10.0%
Solubility:
Hot Water: Cold Water: 5.62 g/100 ml @ -1.1°C
Ethanol: Infinitely soluble Other: Infinitely soluble in ether
DOT Classification:
Coast Guard Classification:

TOXICOLOGY: Butyric acid is not particularly toxic.

OTHER HAZARDS: Moderate fire hazard when exposed to heat or flame. It can react with oxidizing materials.

# CADMIUM, CADMIUM CHLORIDE

## CADMIUM

CHEMICAL FORMULA: Cd

GENERAL DESCRIPTION: Silver-white malleable metal.
Atomic Wt.: 112.41 Melting Pt.: 320.9° C Boiling Pt.: 767°C
Density: (Solid) 8.642 g/cc (Gas)
Vapor Pressure: 1 mm @ 394°C
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Insoluble Cold Water: Insoluble
Ethanol: Other: Hot sulfuric acid, ammonium nitrate
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Cadmium is not found as a free mineral in nature. It is prepared commercially as a by-product of primary metal industries, especially the zinc industry. It is found in zinc, lead and copper ores and in other ores which contain zinc minerals. It separates out with zinc when ores containing several minerals are separated. Cadmium compounds contain cadmium mainly in the devalent state.

Cadmium ore is mixed with sodium chloride and coal or coke and heated in a sintering furnace. The dust and chloride fume is digested with sulfuric acid and then purified by distillation or electrolysis.

Cadmium is also produced from the purification of zinc sulfate solutions, from zinc sulfide manufacter, from the purification of zinc solutions after electrolytic zinc manufacture and from lead smelting.

Large-scale commercial manufacturing facilities for cadmium metal are: Amax, Blackwell, Oklahoma; Asarco, Denver, Colorado; Asarco, Corpus Christi, Texas; American Zinc Company, East St. Louis, Illinois; Anaconda, Great Falls, Montana; and New Jersey Zinc, Depue, Illinois.

USES: The chief use is in electroplating iron and steel. Cadmium plating operations include aircraft components, automobiles, electrical and electronic apparatus, household appliances, radio and television sets, hardware and fasteners. Cadmium metal is also used in pigments, plastic alloys, nickel-cadmium batteries, fungicides, nuclear energy applications, phosphors for television tubes, photography, lithography, process engraving, glass, x-ray screens, and in compounds for curing rubber.

## CADMIUM CHLORIDE

CHEMICAL FORMULA: $Cd\ Cl_2$

GENERAL DESCRIPTION: Colorless crystals.
Molecular Wt.: 183.32 Melting Pt.: 568° C Boiling Pt.: 960° C
Density: (Solid) 4.047 g/cc @ 25°C (Gas)
Vapor Pressure: 10 mm @ 656° C, 10 mm @ 797° C
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 147 g/100 g @ 100°C Cold Water: 90 g/100 g @ 0°C
Ethanol: Slightly soluble Other: 1.52 g/100 ml @ 15°C, insoluble in acetone & ether.
DOT Classification:
Coast Guard Classification:

MANUFACTURE: By dissolving the metal in aqueous hydrochloric acid and evaporating in a stream of hydrogen chloride gas and by dissolving the oxide or carbonate in hydrochloric acid.

Manufacturers of cadmium chloride are: Allied Chemical Corporation, Marcus Hook, Pennsylvania; J.T. Baker Chemical Company, Phillipsburg, New Jersey; Chemetron Corporation, New Brunswick, New Jersey; The Harshaw Chemical Co., Cleveland, Ohio; Mallinckrodt Chemical Works, St. Louis, Missouri.

USES: In photography, in dyeing and calico printing, in the vacuum tube industry, in the manufacture of cadmium yellow, special mirrors, as an ice nucleating agent, in lubricants, and in the analysis of sulfides to absorb the hydrogen sulfide.

TOXICOLOGY: The inhalation of cadmium dusts or fumes affects the respiratory tract primarily, and may also affect the kidneys. Even brief exposure to high concentrations may result in pulmonary edema and death. In fatal cases fatty degeneration of the kidneys have been noted. Ingestion of cadmium results in a gastrointestinal type of poisoning.

Inhalation of the dust or fumes may cause dryness of the throat, coughing, headache, a sense of constriction in the chest, shortness of breath (dyspnea) and vomiting. More severe exposure results in marked lung changes, with persistent cough, pain in the chest, severe dyspnea and prostration which may terminte fatally. X-ray changes are usually similar to those seen in broncho-pneumonia. The urine is frequently dark. These symptoms are ususally delayed for some hours after exposure, and fatal concentrations may be breathed without sufficient discomfort to warn the workman to leave the exposed area.

Ingestion of cadmium results in sudden nausea, salivation, vomiting, diarrhea and abdominal pain. Symptoms begin almost immediately after ingestion.

A yellow discoloration of the teeth has been reported in workers exposed to cadmium.

In fish oxygen inhibition occurs at levels as low as 0.0033 micromoles/ml and can be of such severity as to cause the death of fish particularly the bluegill. Expressed as cadmium, data indicates that the acute lethal level for fish varies from about 0.01 to about 10 mg/liter depending on the test animal the types of water, temperature and time of exposure. Cadmium acts synergistically with other substances to increase toxicity.

The relative oral $LD_{50}$ value to the rat is 88 mg/kg for cadmium chloride. The Threshold Limit Value (TLV) in air is 0.2 mg/cubic meter for cadmium and cadmium chloride. The permissable criteria for soluble cadmium in public water supplies is 0.01 mg/liter.

The Booz-Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Cadmium | 3 | 3 | 1 | 3 | 0 | 0 | 2 | 1 | 2 |
| Cadmium Chloride | 3 | 3 | 3 | 3 | 3 | 3 | 2 | 1 | 2 |

OTHER HAZARDS: The fire and explosive hazard of cadmium metal in the form of dust is moderate when exposed to heat or flame or by reaction with oxidizing materials.

HANDLING, STORAGE, TRANSPORTATION: Care should be exercised in handling cadmium and its compounds because of their high toxicity. In case of skin contact wash with plenty of soap and water. Store away from food and feeds or any other material intended for human or animal consumption.

DISPOSAL/REUSE: The major sources of cadmium waste are the electroplating industry, nickel-cadmium battery manufacturers, paint manufacturers and paint residue left in old containers. The total amount of cadmium waste from the electroplating industry is estimated to be 1.44 million pounds per year. The greater portion of cadmium in air and water waste streams can be recovered for reuse. For the safe disposal of cadmium and cadmium chloride into the environment, the following Provisional Limits are recommended:

| Contaminant in Air | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Cadmium Metal (powder) | 0.002 mg/M$^3$ | 0.01 TLV |
| Cadmium Chloride | 0.002 mg/M$^3$ | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Cadmium Metal (powder) | 0.01 ppm | Drinking Water Standard |
| Cadmium Chloride | 0.01 ppm | Drinking Water Standard |

EVALUATION OF WASTE MANAGEMENT:

## Removal from Air

For removal of cadmium from air electrostatic precipitators, bag houses and cyclones are used for abatement, but there is little information known about the specific application of these procedures for controlling cadmium pollution.

## Removal for Water

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Adsorption with activated-carbon bed | Satisfactory |
| Coagulation and filtration | Adequate |
| Ion exchange | Adequate |
| Reverse Osmosis | Not satisfactory, doesn't reduce the cadmium sufficiently |

For concentrated cadmium waste disposal, coagulation with lime followed by sedimentation and sand filtration is the only proven and adequate treatment method.

APPLICABILITY TO NATIONAL DISPOSAL SITES: Cadmium and cadmium compounds are considered as candidate waste stream constituents for National Disposal Sites due to the extremely high degree of toxicity of all cadmium compounds, the nondegradable nature of the toxic cadmium component of all cadmium compounds, cadmium wastes are present in sizable quantities, a significant amount of cadmium waste is contributed by small plating shops where treatment is either technically or economically infeasible and the cadmium hydroxide waste should be disposed of in California Class 1 type landfills only and are not being adequately handled at present.

CALCIUM CHLORIDE, CALCIUM HYDROXIDE, POTASSIUM SULFATE, CALCIUM OXIDE

## CALCIUM CHLORIDE

CHEMICAL FORMULA: $CaCl_2$

GENERAL DESCRIPTION: Colorless, very hygroscopic, crystalline solid.
Molecular Wt.: 110.99 Melting Pt.: 772°C Boiling Pt.: >1600°C
Density: (Solid) 2.15 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 159 g/100 ml @ 100°C Cold Water: 74.5 g/100 ml @ 20°C
Ethanol: Soluble Other: Soluble in acetic acid-acetone
DOT Classification:
Coast Guard Classification:

MANUFACTURE: About 50-60% of the calcium chloride sold in the U.S. is manufactured from natural brines.

USES: As a dehydrating and drying agent for organic liquids and in desiccators, for drying gases, in refrigeration plants to make brine, in control of snow and ice on highways and streets, in dust control on secondary roads, unpaved streets and highway shoulders, in freezeproofing of coal and ores, in both shipping and stockpiling, and in concrete mixes to give quicker initial set, high early strength and greater ultimate strength.

## CALCIUM HYDROXIDE

CHEMICAL FORMULA: $Ca(OH)_2$

GENERAL DESCRIPTION: Colorless crystalline solid. Also called hydrate lime and slaked lime. Absorbs $CO_2$ from the air.
Molecular Wt.: 74.09 Melting Pt.: $-H_2O$@580°C Boiling Pt.: Decomposes
Density: (Solid) 2.24 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 0.077 g/100 ml @ 100°C Cold Water: 1.85 g/100 ml @ 0°C
Ethanol: Insoluble Other: Soluble in acids and ammonium salts.
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Commercially prepared from brine.

USES: Manufacture of mortars, plastics, cements, soda ash by the Solvay method, in dehairing hides, in water paints, as antiemetic and in infant feeding formulas to decrease sizes of curds formed from cow's milk.

## CALCIUM OXIDE

CHEMICAL FORMULA: CaO

GENERAL DESCRIPTION: Colorless crystalline solid. Also called unslaked lime, quick lime and burnt lime. Absorbs $CO_2$ and water.
Molecular Wt.: 56.08 Melting Pt.: 2580°C Boiling Pt.: 2850°C
Density: (Solid) 3.37 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility: decomposes decomposes
Hot Water: 0.07 g/100 ml @ 80°C Cold Water: .13 g/100 ml @ 10°C
Ethanol: Other: Soluble in acids
DOT Classification:
Coast Guard Classification:

MANUFACTURE: From calcination of limestone in a kiln.

USES: In the manufacture of mortar and plastics, in various metallurgical processes, in the manufacture of slaked lime, as a desiccant, in the manufacture of bleaching agents, pesticides, inorganic and organic salts of calcium, and chlorinated lime, in water purification and treatment, in paper pulp processing, in the manufacture of glass and ceramics, in deodorizing vegetable oils and in dehairing hides.

## POTASSIUM SULFATE

CHEMICAL FORMULA: $K_2SO_4$

GENERAL DESCRIPTION: Colorless or white crystalline solid. Readily absorbs $CO_2$ from air.
Molecular Wt.: 174.27 Melting Pt.: 1069°C Boiling Pt.: 1689°C
Density: (Solid) 2.662 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 24.1 g/100 ml Cold Water: 12 g/100 ml @ 25°C
Ethanol: Insoluble Other:

DOT Classification: ____________________________
Coast Guard Classification: ____________________

MANUFACTURE: From langbeinite ore, $K_2SO_4 \cdot 2MgSO_4$, from Searles Lake brine, by the reaction: $2KCl + H_2SO_4 \longrightarrow K_2SO_4 + 2HCl$ and by burning sulfur with excess air mixed with steam and then passing the gaseous mixture through a bed of porous KCl briquets.

USES: As fertilizers, in the manufacture of potassium alum, potassium carbonate, glass, and GRS latex rubber, in smokeless powder and as an analytical reagent.

TOXICOLOGY: Generally speaking, calcium compounds are non-toxic. Calcium chloride is completely innocuous. Calcium hydroxide is irritating to the skin and respiratory system. In the form of dust calcium hydroxide can cause dermatitis and irritation of the eyes and mucous membranes. Potassium sulfate is non-toxic.

The Threshold Limit Value (TLV) and Lethal Doses are as follows:

| Contaminant | TLV, mg/M$^3$ | Lethal Dose |
|---|---|---|
| Calcium Chloride | - | or $LD_{50}$ 4000 mg/kg rat |
| Calcium Hydroxide | - | or $LD_{50}$ 7340 mg/kg rat |
| Potassium Sulfate | - | sc $LD_{50}$ 3000 mg/kg guinea pig |
| Calcium Oxide | 5 | |

The Booz-Allen Ratings are:

| Contaminant | HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Calcium Chloride | 1 | 1 | 1 | 1 | 2 | U | 2 | 1 | 2 |
| Calcium Hydroxide | - | - | - | - | - | - | - | - | - |
| Potassium Sulfate | 1 | 3 | 2 | 2 | 2 | U | 2 | 1 | 1 |
| Calcium Oxide | 3 | 2 | 2 | U | 2 | U | 1 | 2 | 1 |

OTHER HAZARDS: Calcium chloride and calcium oxide generate much heat when dissolved in water, due to the heat of solution and the reaction of calcium oxide to calcium hydroxide.

HANDLING, STORAGE, TRANSPORTATION: In storage, these materials must be kept tightly closed and dry because most of them absorb moisture and/or carbon dioxide from the air. Adequate ventilation and dust control should be maintained particularly for storing and handling calcium hydroxide.

DISPOSAL/REUSE: Industrially, contaminated materials will not be considered for reuse, based on economic considerations. If these materials are to be released into the environment, the following Provisional Limits should be considered:

| Contaminant in Air | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Calcium Chloride | 0.07 mg/M$^3$ as HCl | 0.01 TLV for HCl |
| Calcium Hydroxide | 0.05 mg/M$^3$ | 0.01 TLV for CaO |
| Potassium Sulfate | 0.01 mg/M$^3$ as $H_2SO_4$ | 0.01 TLV for $H_2SO_4$ |
| Calcium oxide | 0.05 mg/M$^3$ | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Calcium Chloride | 250 ppm (mg/l) as Cl | Drinking Water Standard |
| Calcium Hydroxide | 0.25 ppm (mg/l) | Stokinger and Woodward Method |
| Potassium Sulfate | 250 ppm (mg/l) as $SO_4$ | Drinking Water Standard |
| Calcium Oxide | 0.25 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE DISPOSAL METHODS:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Carbonate precipitation of the chlorides with soda ash and recovery of the $CaCO_3$ and discharge of the brine to sewers or any other waterways. | Satisfactory |
| Neutralization with HCl and carbonate precipitation for contaminated CaO and $Ca(OH)_2$ and treatment of the chlorides as above or diluted and discharged to sewers or streams. | Satisfactory |
| Potassium sulfate and calcium chloride dilute streams may be discharged to streams. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: The chemicals discussed in this report are probable candidates for municipal disposal and are not considered waste stream candidates for National Disposal Sites.

## CAPROLACTAM

CHEMICAL FORMULA: $C_6H_{11}NO$;

GENERAL DESCRIPTION: White crystalline solid. Also called 2-oxohexamethyleneimine.

Molecular Wt.: 113.16 Melting Pt.: 69°C Boiling Pt.: ________
Density: (Solid) ________ (Gas) ________
Vapor Pressure: 6 mm @ 120°C
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Wt%): Lower ________ Upper ________
Solubility:
Hot Water: ________ Cold Water: ________
Ethanol: ________ Other: ________
DOT Classification: ________
Coast Guard Classification: ________

TOXICOLOGY: May be an irritant.

OTHER HAZARDS: It emits toxic fumes when heated to decomposition.

HANDLING, STORAGE, TRANSPORTATION: Store in a cool well ventilated place.

# CARBON DISULFIDE

**CHEMICAL FORMULA:** $CS_2$

**GENERAL DESCRIPTION:** Highly flammable colorless liquid. Also called carbon bisulfide, dicarbonic anhydride.
Molecular Wt.: 76.14 Melting Pt.: -112°C Boiling Pt.: 45°C
Density: (Liquid) 1.2628 gm/cc @ 20°C (Gas) 2.67 gm/l @ 20°C
Vapor Pressure: 400 mm @ 28°C 760 mm @ 26.5°C
Flash Pt.: -30°F; -22°F Autoignition Temperature: 100°F
Explosive Limits in Air (Wt%): Lower ______ Upper 50%
Solubility:
Hot Water: ______ Cold Water: Very slightly Ethanol: Miscible
Other: Soluble in chloroform, ether, benzene, carbon tetrachloride and oils.
DOT Classification: Flammable liquid, red label
Coast Guard Classification: Flammable liquid, red label

**MANUFACTURE:** By the reduction of sulfur with methane in the presence of a silica-gel catalyst at 570 to 620°C and 20 to 30 psig.

**USES:** Essential ingredient of xanthates used in the manufacture of viscose rayon, cellophane, cellulose sponge, non-woven fabrics and others. It is the raw material for carbon tetrachloride. Carbon disulfide is an excellent solubilizer for oils, waxes, sulfur and sulfur compounds. Used for removing paraffin from pipelines and oil well casings. Used for extraction of vegetable oils. Absorbent clays and petroleum catalysts are regenerated with $CS_2$. Used in emulsion polymerization, as nitrocellulose and polyvinyl solvents, in recovery of sulfur ores, and as a solvent in vaporphase curing of rubber sheets. Used in agriculture as grain fumigants, soil conditioners, herbicides, rodenticides and nematocides. Used as insecticidal fumigant for nursery stocks and soil treatment against beetles. Used in treatment of wood to improve flexural strength, as a corrosion inhibitor and in deworming of livestock.

**TOXICOLOGY:** Carbon disulfide poisoning is usually caused by breathing the fumes. Poisoning can be through the skin. Skin contact can cause local inflammation.

The chief toxic effect is on the central nervous system, acting as a narcotic an anesthetic in acute poisoning with death following from respiratory failure. In chronic poisoning, the effect on the nervous system is one of central and peripheral damage, which may be permanent if the damage has been severe. A secondary effect may be anemia. Neuritis and disturbance of vision are the commonest early changes. Often there is pain in the affected parts, particularly in the limbs. Increasing loss of strength follows. Wasting of muscles may occur. Mental symptoms vary from simple excitation or depression irritability in mild cases to mental deterioration, Parkinsonian paralysis and even insanity. These changes are accompanied by insomnia, loss of memory and personality changes. Chronic fatigue is a very common complaint.

The Threshold Limit Value (TLV) and Maximum Allowable Concentration are 20 ppm and 60 mg/M³ respectively.

The Booz-Allen Ratings are:

| | HUMAN | | | BIOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 2 | 1 | 2 | 2 | 1 | 2 |

OTHER HAZARDS: Carbon disulfide is a highly flammable, volatile liquid with a low flash point (-22°F), wide explosive range and an autoignition temperature of 100°C (212°F). Contact with exposed steam lines or the surface of an ordinary electric light bulb may cause ignition. Carbon disulfide vapor when mixed with air or oxygen in certain concentrations, is flammable and explosive. Carbon disulfide reacts violently or explosively with azides, chlorine in the presence of iron, chlorine monoxide and fluorine.

HANDLING, STORAGE, TRANSPORTATION: Due to the high degree of flammability and extreme volatility of carbon disulfide, strict ICC precautions regulate the loading, handling, transporting and labelling of containers. Non-sparking tools and hose connections must be used and the container should be grounded to prevent accumulation of static electricity. Transfer is accomplished by water padding, nitrogen displacement or pumping. Vapors should be purged from empty drums with steam while empty tank cars must have four "Dangerous Empty" placards in place.

Drums and other containers of carbon disulfide should be stored in a cool, dry, and well-ventilated place away from acute fire hazards. Storage should be limited to minimize the hazard and the storage area should be of fire-resistant construction and equipped with sprinklers and/or portable fire extinguishers.

DISPOSAL/REUSE: The major use (65%) of carbon disulfide is in the production of cellophane and rayon by extraction of the desired compounds as xanthates. After extraction, the carbon disulfide is regenerated and reused.

When carbon disulfide is used as a chemical intermediate in production, any unreacted material is carefully recovered for reuse.

Carbon disulfide used as an extraction solvent in emulsion polymerization and in extractive regeneration is recycled indefinitely.

In the agricultural field, mixtures of carbon disulfide escape directly into the environment and cannot be recovered.

Recommended Provisional Limits for carbon disulfide in the environment are as follows:

| Carbon Disulfide in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.2 ppm | .01 TLV |
| Water and Soil | 1.0 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES: The industries that use carbon disulfide as a chemical intermediate or as a solvent recycle as much material as possible. This is the method of choice, whenever possible.

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Controlled incineration with $SO_2$ scrubber | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: The wastes generated in the manufacture and use of carbon disulfide can best be handled and treated at or near the site of generation by recycling or incineration. Since these methods represent common industrial technology, carbon disulfide is not judged to be a candidate waste stream constituent for National Disposal Sites.

# CHLORINE

CHEMICAL FORMULA: $Cl_2$

GENERAL DESCRIPTION: Greenish yellow gas, liquid or crystalline solid.
Molecular Wt.: 70.906 Melting Pt.: -101°C Boiling Pt.: -34.6°C
Density: (Solid) 1.468 g/cc @ 0°C (Gas) 3.214 g/l @ 0°C
Vapor Pressure: 85.46 psia @ 70°F, 151.12 psia @105°F, 174.69 psia @ 115°F
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 0.54% @ 30°C Cold Water: 0.8% @ 10°C
Ethanol: Reacts Other: Soluble in alkaline water
DOT Classification: nonflammable gas, green label, 150 lbs
Coast Guard Classification: non flammable gas, green gas label
MCA Warning Label
IATA Classification: Nonflammable gas, green label
Not acceptable (passenger) 70 kilograms (cargo)

MANUFACTURE: Diaphragm and mercury electrolytic cells and molten salt cells.

USES: Hydrochloric acid manufacture, organic chlorinations, pulp bleaching, metallurgical processing and bleach manufacture.

TOXICOLOGY: (Human Toxicology)-Chlorine is an extremely powerful vesicant and respiratory irritant. Its action is that of a severe irritant rather than as a toxic agent; high concentrations cause pulmonary edema which may be fatal. Lower concentrations cause coughing, smarting of the eyes, chest discomfort, nausea, and vomiting. The effects of different concentrations are shown below:

| EFFECT | CHLORINE, ppm |
|---|---|
| Min. Conc. detectable by odor | 3.5 |
| Min. Conc. causing throat irritation | 15 |
| Min. Conc. causing coughing | 30 |
| Min. Conc. causing slight symptoms after several hours | 1 |
| Max. Conc. that can be breathed for one hour without damage | 4 |
| Conc. dangerous in 30 minutes | 40-60 |
| Conc. likely to be fatal after a few deep breaths | 1,000 |
| TLV for 8-hour exposure | 1 |

Liquid chlorine causes severe irritation and blistering of the skin.

(Aquatic Toxicology)-The toxicity of chlorine solutions in water is usually not a problem. Dissolved chlorine reacts rapidly with organic and other oxidizable substances in natural streams and chlorine escapes from water at a pH of less than 7 at a rapid rate.

(Plant Toxicology)-At concentrations of 0.1 to 1.5 ppm of chlorine gas, the most common symptoms of chlorine poisoning of plants have been found to be necrosis and bleaching of the foliage. Bleaching of the leaves occurs from exposure to low concentrations of chlorine.

The Booz-Allen Ratings are:

| | HUMAN | | | BIOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 2 | 1 | 2 | 1 | 0 | 2 | 2 | 2 |

OTHER HAZARDS: Most chlorine is very corrosive to all of the common materials of construction except high silica iron, monel, hastelloy C, silver and noble platinum metals. At low pressures wet chlorine can be handled in chemical stoneware, glass, porcelain, and certain plastics.

Chlorine is capable of supporting combustion of many materials. It also reacts very rapidly with many compounds, both organic and inorganic.

HANDLING, STORAGE, TRANSPORTATION: Adequate procedures for safe handling, transportation and storage of chlorine are provided by Matheson in the Matheson Gas Data Book. It is shipped in 100-lb and 150-lb. steel cylinders, single unit tank cars of 30,000 lbs and multi-unit tank cars of 15 one-ton units.

DISPOSAL REUSE: Current practice in chlorine disposal usually involves recycling, recovery, alkaline scrubbing, or venting. The safe disposal of chlorine must take into account the safe release of chlorine to the environment. The Recommended Provisional Limits for chlorine in the atmosphere, in potable water sources, and in marine habitates are:

| Chlorine as Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.03 mg/M³ | 0.01 TLV |
| Water and Soil | 0.15 mg/L | Stokinger & Woodward Method |
| Marine Habitats | 0.003 | 0.01 Fish Toxicity |

EVALUATION OF WASTE MANAGEMENT PRACTICES: In 1969, 9.5 million tons of chlorine were produced with an estimated 78,200 tons being emitted to the atmosphere. A summary of the chlorine emissions and their sources is presented below:

| SOURCE | CHLORINE EMISSIONS, TONS |
|---|---|
| Chlorine Manufacture | 47,000 |
| Hydrochloric Acid Manufacture | 800 |
| Chemical and Industrial Processes: | |
| Organic Chlorination | 8,500 |
| Pulp Bleaching | 18,000 |
| Metallurgical Processing | 2,000 |
| Bleach Manufacture | 900 |
| Miscellaneous | 1,000 |

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Recycling and recovery | Satisfactory |
| Water scrubbing followed by alkaline scrubbing of dilute streams | Satisfactory |
| Silica gel absorption | Satisfactory |
| Reaction with sulfur | Not recommended due to the disposal problem of sulfur chlorides produced. |
| Carbon tetrachloride scrubbers | Not recommended due to spills and losses of carbon tetrachloride. |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Chlorine waste can be handled adequately at industrial site. Some capacity will be needed at National Disposal Sites to process occasional tank-car or smaller lots which are required to be disposed of in a safe, pollution free manner and for secondary gas streams generated within the National Disposal Site as a result of processing other waste.

# HALOGENATED HYDROCARBONS
(Chloroform, Epichlorohydrin, and Chlorinated Hydrocarbons in general)

## CHLOROFORM

CHEMICAL FORMULA: $CHCl_3$

GENERAL DESCRIPTION: Colorless liquid with a heavy, ethereal odor. IUC Name: Trichloromethane.
Molecular Wt.: 119.38 Melting Pt.: -63.5°C Boiling Pt.: 61.2°C
Density: (Liquid) 1.4916 g/cc @ 18°C (Gas)
Vapor Pressure: 15 psig @ 84°C; 60 psig @ 120° C
Flash Pt.: Nonflammable Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Slightly Cold Water: Slightly Ethanol: Miscible
Other: Miscible in all proportions in ether, acetone, benzene, and ligroin.
DOT Classification:
Coast Guard Classification:

## EPICHLOROHYDRIN

CHEMICAL FORMULA:
$\underbrace{CH_2CH}_{O}CH_2Cl$

GENERAL DESCRIPTION: Colorless, mobile liquid, irritating chloroform-like odor. IUC Name: 1-chloro-2,3-epoxypropane. Also called γ-epichlorohydrin, γ-chloropropylene oxide, chloromethyloxirane.
Molecular Wt.: 92.53 Melting Pt.: -25.6°C Boiling Pt.: 116.5°C
Density: (Liquid) 1.1801 g/cc @ 20°C (Gas) 3.29 g/l
Vapor Pressure: 10 mm @ 16.6°C 100 mm @ 62°C 400 mm @ 98°C
Flash Pt.: 105°F (O.C.) Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Decomposes Cold Water: Slightly Ethanol: ∞
Other: Soluble in benzene, ether (∞), chloroform, trichloroethylene, carbon tetrachloride, immiscible in petroleum hydrocarbons.
DOT Classification:
Coast Guard Classification:
MCA warning label

MANUFACTURE: Most chlorinated hydrocarbons are produced by addition and/or substitution reactions.

USES: Chlorinated hydrocarbons are used as refrigerant propellants, as solvents, soil fumigants, insecticides, medical and veterinary uses and in organic synthesis of other compounds.

Chloroform is one of the chlorinated hydrocarbons used in the medical and veterinary field and to make refrigerants.

Epichlorohydrin is used in epoxy resins.

TOXICOLOGY: In aliphatic hydrocarbons the substitution of a chlorine atom greatly increases the anesthetic action of the compound and the chlorine derivative is usually less specific in it action and may affect other tissues of the body in addition to the central nervous system. In many cases the chlorine derivative is quite toxic. The chlorinated hydrocarbons are also irritants to the eyes and mucous membranes. Repeated exposure to the skin may cause dermatitis and may be absorbed through the skin. Chloroform, in addition to its narcotic effect, may cause damage to the liver heart & kidneys. It is hard to predict the toxicity of the aromatic hydrocarbons. In most cases the aromatic chlorine compounds are no more toxic and are frequently less toxic than the corresponding aromatic hydrocarbons.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations are:

| | TLV | | MAC |
|---|---|---|---|
| | ppm | $mg/M^3$ | ppm |
| Chloroform | 25 | 120 | 50 |
| Epichlorohydrin | 5 | 19 | -- |

The Booz-Allen Ratings on these material are:

| | HUMAN | | | ECOLOGY | | | EXPLOSIVE | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Chloroform | 3 | 1 | 1 | 2 | 3 | 0 | 2 | 2 | 2 |
| Epichlorohydrin | 3 | 3 | 3 | 2 | 3 | 0 | 2 | 1 | 2 |

OTHER HAZARDS: When heated to decomposition all chlorohydrocarbons give off noxious and highly toxic fumes, including chloroacids, free chlorine and phosgene. They will also react explosively when they come into contact with alkaline and alkaline earth metals. They may be very corrosive to aluminum.

HANDLING, STORAGE, TRANSPORTATION: Handle in a well-ventilated area. Wear protective clothing and respirators when necessary, avoid skin contact and inhalation. In cases of accidental contact, all contaminated clothing should be removed instantly and the skin washed thoroughly with soap and water.

Store in a dry, cool, well-ventilated area away from acute fire hazards.

DISPOSAL/REUSE: In manufacture there is a residue left which needs disposal although some material is recycled or reclaimed. In most cases of use however, the materials are lost to the atmosphere. Users of large volume chemical intermediates, including chloroform and epichlorohydrin recycle any unused materials. Usually these material do not come into contact with aqueous media, so discharge of dilute aqueous streams is not a problem.

For disposal of these materials the following Provisional Limits are recommended:

| Contaminant in Air | Provisional Limit<br>ppm | <br>mg/M³ | Basis for Recommendation |
|---|---|---|---|
| Chloroform | 0.25 | 1.2 | 0.01 TLV |
| Epichlorhydrin | 0.05 | 0.19 | Based on similar compounds |

| Contaminant in Water and Soil | Provisional Limit<br>ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Chloroform | 6 | Stokinger & Woodward Method |
| Epichlorohydrin | 0.95 | Stokinger & Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES: Recycling or reclaiming is the preferred method of handling waste from the chlorinated hydrocarbons when possible.

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Incineration with the use of an acid scrubber. | Satisfactory |
| Landfill of residue and sludges | Not satisfactory unless totally isolated from ground and surface water due to long term hazard. |

APPLICABILITY TO NATIONAL DISPOSAL SITES: These materials can be handled best at the site of generation by incineration. Except in extreme cases these compounds are not considered candidates for National Disposal Site disposal.

## CHROMIC ACID

CHEMICAL FORMULA : $CrO_3$

GENERAL DESCRIPTION: Red crystalline solid. Poisonous, powerful oxidizer. IUC Name: Chromium trioxide. Also called chromic anhydride

Molecular Wt.: 100.01 Melting Pt.: 197°C d Boiling Pt.: ____
Density: (Solid) 2.70 g/cc @ 20°C (Gas) ____
Vapor Pressure: ____
Flash Pt.: ____ Autoignition Temperature: ____
Explosive Limits in Air (Wt%): Lower ____ Upper ____
Solubility:
Hot Water: 206.7 g/100 g @ 100°C Cold Water: 164.9 g/100 g @ 0°C
Ethanol: ____ Other: $H_2SO_4$
DOT Classification: Oxidizing material*
Coast Guard Classification: Oxidizing material

* In solution DOT classification is corrosive liquid, white label, 1 gallon maximum.

MANUFACTURE: Produced by the reaction of sodium dichromate and sulfuric acid and by sulfuric acid charged with sulfur dioxide.

USES: Almost exclusively in the metal finishing industry. About half of this is used in direct decorative chromic plating. Annual consumption is approximately 30,000 tons with 90% in the metal treating industry and the remaining 10 percent used for catalyst manufacture, refractory or exported.

SOURCES AND TYPES OF WASTE: Large amounts from the metal finishing and chrome plating industry.

TOXICOLOGY: Very corrosive and strong oxidizer. In contact with skin or mucous membranes, it can cause ulcerous lesions which heal slowly. The salts of chromic acid have also been associated with lung cancer. The Threshold Limit Value for hexavalent chromates is 0.1 mg/M$^3$ in air. Drinking water should contain no more than 0.05 ppm. Should be kept away from terrestorial plant life. No exact information on aquatic plant and animal life, but is probably very harmful.

The Booz-Allen Ratings for chromic acid are:

| HUMAN | | | BIOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 2 | 3 | 0 | 2 | 1 | 2 |

OTHER HAZARDS: Should not be mixed with organic or reducing agents. Even dilute organic solutions can produce violent reactions if heated. Concentrated aqueous solutions will attack some metals.

HANDLING, STORAGE, TRANSPORTATION: Should be stored away from high temperatures or reducing agents. The creation of $CrO_3$ dust must be avoided during handling, storage and transportation. Workers should be adequately protected from contact of chromium trioxide with skin, eyes or internal organs. Adequate supervising control and employee education of the hazards is recommended.

DISPOSAL/REUSE: Discharge into open waterways is severely restricted. U.S. Public Health Service recommends 0.05 ppm as upper limit in drinking water. The upper limits of hexavalent chromium discharge into municipal sewage systems is normally set at about 0.05 ppm.

For the safe disposal of chromic acid into the environment, the following Provisional Limits are recommended:

| Chromic Acid in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.001 mg/M³ as $CrO_3$ | 0.01 TLV |
| Water and Soil | 0.05 ppm (mg/l) as Cr | Drinking Water Standard |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Reduction and precipitation as hydroxides, with disposal of sludges in either approved landfills or by incineration. | Satisfactory |
| Ion exchange | Satisfactory |
| Electro chemical reduction | Satisfactory |
| Direct precipitation by use of barium or lead salts | Not satisfactory, potential handling problems due to poisonous heavy metals. |
| Ion flotation, electrodialysis, activated carbon absorptions, liquid-liquid extraction, activated carbon reduction, and reverse osmosis. | Promising methods in various styles of development |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Chromic acid is considered as a candidate waste stream constituent for National Disposal Sites.

# COPPER CHLORIDE

## CUPRIC CHLORIDE

CHEMICAL FORMULA: $Cu\,Cl_2$

GENERAL DESCRIPTION: Yellowish-brown, hygroscopic powder.
Molecular Wt.: 134.45 Melting Pt.: 498°C Boiling Pt.: 993° ? decomposes to CuCl
Density: (Solid) 3.054 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 107.9 g/100 ml@100°C Cold Water: 70.6 g/100 ml @ 0°C
Ethanol: 53 g/100 ml @ 15°C Other: 68 g/100 ml in methanol @ 15°C
DOT Classification:
Coast Guard Classification:
IATA Classification: Other restricted articles class B, no label required
11 kilograms (passenger), 45 kilograms (cargo)

USES: Many copper containing compounds are used as fungicides.

## CUPROUS CHLORIDE

CHEMICAL FORMULA: $Cu\,Cl$

GENERAL DESCRIPTION: White crystalline solid. Also called nantokite.
Molecular Wt.: 99.00 Melting Pt.: 422°C Boiling Pt.: 1366°C
Density: (Solid) 3.53 g/cc (Gas)
Vapor Pressure: 1 mm at 546°C
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Insoluble
Ethanol: Other: Soluble in HCl and $NH_4OH$.
DOT Classification:
Coast Guard Classification:

USES: Many copper containing compounds are used as fungicides.

TOXICOLOGY: May cause irritation of the skin and conjunctivae which may be on an allergic basis. Inhalation of copper dust has caused, in animals, hemolysis of the red blood cells, deposition of hemofuscin in the liver and pancreas, and injury to the lung cells. Injection of the dust has caused cirrhosis of the liver and pancreas, and a condition closely resembling hemochromatosis, or bronzed diabetes. However, considerable trial exposure to copper compounds has not resulted in such disease.

OTHER HAZARDS: Chlorides when heated to decomposition or on contact with acids or acid fumes evolve highly toxic chloride fumes.

# CUMENE HYDROPEROXIDE

CHEMICAL FORMULA:

GENERAL DESCRIPTION: Colorless to pale-yellow liquid. Also called α,α-dimethyl benzyl hydroperoxide.
Molecular Wt.:__________ Melting Pt.:________ Boiling Pt.: 153°C
Density: (Liquid) 1.05 g/cc ________ (Gas)__________
Vapor Pressure:
Flash Pt.: 175°F ________ Autoignition Temperature:________
Explosive Limits in Air (Wt%): Lower________ Upper________
Solubility:
Hot Water:________ Cold Water:________ Ethanol:________
Other:________
DOT Classification:________
Coast Guard Classification:________

# DIAZINON

CHEMICAL FORMULA: $C_{12}H_{21}N_2O_3PS$

GENERAL DESCRIPTION: Liquid with faint ester-like odor. Also called G-24, 480, O, O-diethyl-O, 2-isopropyl, 4-methyl-pyrimidyl thiophosphate.

Molecular Wt.: 304.4 Melting Pt.:________ Boiling Pt.: 84°C @0.002

Density: (Liquid) 1.116 g/cc @ 20°C (Gas)________________/mm

Vapor Pressure:________________

Flash Pt.:________________ Autoignition Temperature:__________

Explosive Limits in Air (Wt%): Lower__________ Upper__________

Solubility:

Hot Water:__________ Cold Water:__________ Ethanol:__________

Other:__________

DOT Classification:________________

Coast Guard Classification:________________

IATA Classification: Other restricted articles, class A, no label required no limit (passenger and cargo)

TOXICOLOGY: Very toxic by absorption through the skin inhalation or by ingestion. It is similar to parathion which can cause death from a small amount being splashed on the skin if not washed off immediately and all contaminated clothing is not removed. All of the organophosphorus insecticides function by cholinestrase inhibition. This enzyme is an essential constituent of the nervous system. Symptoms of parathion poisoning are headache, giddiness, blurred vision, weakness, nausea, cramps, diarrhea, discomfort of the chest, sweating, miosis, tearing, salivation, pulmonary edema, cyanosis, papilledema, convulsions, coma and loss of reflexes and sphincter control.

## DINITROBENZENE

Three isomers exist

### o - DINITROBENZENE

CHEMICAL FORMULA: $C_6H_4(NO_2)_2$,

GENERAL DESCRIPTION: Colorless to yellowish crystalline solid. IUC Name: 1,2 - dinitrobenzene
Molecular Wt.: 168.11 Melting Pt.: 118°C Boiling Pt.: 302.8°C @773 mm
Density: (Solid) 1.571 g/cc at °C (Gas) 5.79 g/l
Vapor Pressure:
Flash Pt.: 302°F Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Slightly Ethanol: Soluble
Other: Very soluble in chloroform and hot alcohol
DOT Classification:
Coast Guard Classification:

### m - DINITROBENZENE

CHEMICAL FORMULA: $C_6H_4(NO_2)_2$,

GENERAL DESCRIPTION: Colorless to yellowish crystalline solid. IUC Name: 1,3 - dinitrobenzene
Molecular Wt.: 168.11 Melting Pt.: 90°C Boiling Pt.: 291°C @756 mm
Density: (Solid) 1.571 g/cc @ 0°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Insoluble Ethanol: Very soluble
Other: Soluble in ether, chloroform. Very soluble in benzene.
DOT Classification:
Coast Guard Classification:

### p - DINITROBENZENE

CHEMICAL FORMULA: $C_6H_4(NO_2)_2$,

GENERAL DESCRIPTION: Colorless to yellowish crystalline solid. IUC Name: 1, 4 - dinitrobenzene.

Molecular Wt.: 168.11 Melting Pt.: 172°C 90°C Boiling Pt.: 299°C @
Density: (Solid) 1.625 g/cc @ 20°C (Gas) 777 mm
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: Insoluble
Ethanol: Slightly soluble Other: Soluble in chloroform and acetic acid
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Meta-dinitrobenzene is made by direct nitration of benzene using nitric acid and sulfuric acid. Ortho-and para-dinitrobenzene are prepared by oxidation of primary aromatic amines.

USES: As explosives.

TOXICOLOGY: Dinitrobenzene is very toxic. It has an irritating effect on the respiratory system and causes the skin to become bluish in color. It produces anemia, jaundice, enlarged liver or yellow atrophy, degeneration of kidneys and injury to the central nervous system. 1,2-Dinitrobenzene has a Threshold Limit Value of 1 mg/M³ and it may be absorbed through the skin. 1, 4 dinitrobenzene has an oral LD in cats of 29.4 mg/kg.

The Booz-Allen Ratings for ortho-dinitrobenzene are as follows:

| MATERIAL | HUMAN |  |  | ECOLOGICAL |  |  | EXPLOSION |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| o - dinitrobenzene | 3 | 3 | 3 | U | 3 | U | 3 | 2 | 2 |

OTHER HAZARDS: Severe explosion hazards. When heated to decomposition they emit highly toxic fumes of nitrogen and explode.

HANDLING, STORAGE, TRANSPORTATION: When handling avoid contact with the skin. Use protective clothing. Protect from shock and heat. In the Code of Federal Regulations, Title 49, Transportation, these material are classed as Poison B.

DISPOSAL/REUSE: Disposal or reuse of waste streams containing these compounds must take into account their explosive and toxic nature.

Recommended Provisional Limits for dinitrobenzene are as follows:

| Dinitrobenzene in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.01 mg/M³ | .01 TLV |
| Water and Soil | 0.05 ppm (mg/l) | Stokinger & Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

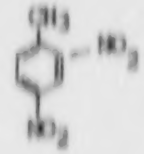
| METHODS OF DISPOSAL | EVALUATION |
|---|---|
| CONCENTRATED NITROBENZENE | |
| Dilution with other combustible materials which are not explosive and incineration under controlled condition, using scrubbers for the effluent gases. | Satisfactory |
| DILUTE DINITROBENZENE | |
| Concentrate waste streams and dispose of by treating as discussed for concentrated dinitrobenzene. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Dinitrobenzene can be treated at the point of generation and is not considered to be a waste stream constituent for National Disposal Sites.

# DINITROTOLUENE

There are five isomers of dinitrotoluene. The description will be given for only 2, 4 - dinitrotoluene.

CHEMICAL FORMULA: $C_6H_3CH_3NO_2$,



GENERAL DESCRIPTION: Yellow crystalline solid. Also called 1-methyl-2-4 dinitrotoluene.

Molecular Wt.: 182.13 Melting Pt.: 69.5°C Boiling Pt.: 300°C
Density: (Solid) 1.521 g/cc (Gas) (slightly decomposes)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Cold Water 0.02 g/100 ml @ 22°C Hot Water Ethanol 30.4 g/100 ml @ 15°C Others Soluble in ether
DOT Classification: Explosive class 2, group D
Coast Guard Classification:
IATA Classification: Poison B, poison label, 1 litre (passenger), 220 litres (cargo)

MANUFACTURE: By the stepwise nitration of toluene with mixed acid (sulfuric and nitric acids).

USES: In explosives, propellants ,polyurethanes and as a dye intermediate. Much is reduced to the diamine and then reacted with phosgene to make toluene diisocyanate

TOXICOLOGY: Dinitrotoluene can enter the body by inhalation, ingestion and absorption through the skin. Skin contact may result in staining of the skin and dermatitis. It may cause irritation of mucous membranes and of the eyes. Symptoms of dinitrotoluene poisoning are dermatitis, gastritis and methaemoglobinema which in turn give rise to cyanosis aplastic anemia and toxic hepatitis. The Threshold Limit Value (TLV) is 1.5 mg/M$^3$ and the Booz-Allen Ratings for 2-4 dinitrotoluene are:

| HUMAN | | | ECOLOGY | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 2 | 0 | 3 | 0 | 3 | 1 | 2 |

OTHER HAZARDS: Dinitrotoluene can be detonated by a very strong initiator.

It may explode when involved in a fire. Fire fighting should be done by remote control. Water, carbon dioxide, dry sodium carbonate or carbon tetrachloride may be used to extinguish burning dinitrotoluene. Its hazard properties are:

Explosion temperature @ 5 seconds: 310°C
Vacuum Stability @ 120°C : 0.04 cc/hr
Friction @ 8 ft/sec : 950 lb.

HANDLING, STORAGE, TRANSPORTATION: When handling, protective clothing, rubber gloves and eye protection should be worn. Avoid skin and eye contact inhalation and ingestion. Dinitrotoluene is shipped in bottles, cans, metal barrels, drums and wooden barrels or kegs with liners.

DISPOSAL/REUSE: For the disposal of dinitrotoluene waste, the following Recommended Provisional Limits for dinitrotoluene in the environment are:

| Dinitrotoluene as a Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.05 ppm (0.015 mg/M$^3$) | .01 TLV |
| Water and Soil | 0.075 mg/l | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| METHODS OF DISPOSAL | EVALUATION |
|---|---|
| Open burning | Unacceptable. This method results in liberation of $NO_x$. |
| Controlled incineration using $NaHCO_3$ or sand-soda ash mixture mixed with the waste and using an afterburner and an alkaline scrubber | Satisfactory |
| Controlled incineration using a solvent for the waste and using an afterburner and an alkaline scrubber | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: It is not anticipated that a National Disposal Site will be necessary for dinitrotoluene. However, National Disposal Sites will probably be necessary for small quantities of explosive and propellant wastes containing dinitrotoluene.

## DIOXANE, PROPYLENE OXIDE, ETHERS

## DIOXANE

There are two possible isomers m-Dioxane and p-Dioxane.

### m - DIOXANE

CHEMICAL FORMULA: $\underline{OCH_2-O-CH_2CH_2-CH_2}$

GENERAL DESCRIPTION: clorless liquid. Also called 1,3-dioxane, trimethylene glycol methylene ether; trimethylene methylene dioxide

Molecular Wt.: 88.10 Melting Pt.: ---- Boiling Pt.: 105°C

Density: (Liquid) 1.03422 g/cc @ 20°C (Gas) ____

Vapor Pressure: ____

Flash Pt.: ____ Autoignition Temperature: ____

Explosive Limits in Air (Wt%): Lower ____ Upper ____

Solubility:

Hot Water: ____ Cold Water: ∞ Ethanol: ∞

Other: ∞ in ether

DOT Classification: ____

Coast Guard Classification: ____

### p - DIOXANE

CHEMICAL FORMULA: $\underline{OCH_2CH_2-OCH_2-CH_2}$

GENERAL DESCRIPTION: Colorless liquid. Also called 1,4-dioxane; diethylene oxide, diethylene dioxide, glycol ethylene ether.

Molecular Wt.: 88.10 Melting Pt.: 10°C Boiling Pt.: 101.1°C

Density: (Liquid) 1.0353 g/cc @ 20°C (Gas) 3.03 g/l

Vapor Pressure: 40 mm @ 25.2°C 100 mm @ 45.1°C

Flash Pt.: 54°F (C.C.) Autoignition Temperature: 45.1°C

Explosive Limits in Air (Wt%): Lower 1.97% Upper 22.2%

Solubility:

Hot Water: ∞ Cold Water: ∞ Ethanol: ∞

Other: Ether, Acetone, Organic solvents acetic acid.

DOT Classification: ____

Coast Guard Classification: ____

MCA warning label

IATA: Flammable liquid, red label

1 lit max. (passenger), 40 lit max. (cargo)

MANUFACTURE: Amsco Division; Ashland Chemical Co.; J.T. Baker Chemical Co.;

Corco Chemical Co.; Grant Chemical Co.; M C & B Manufacturing Chemists; Southland Solvents and Chemical Co.; Stoney-Mueller, Inc.; Union Carbide Corporation.

## PROPYLENE OXIDE

CHEMICAL FORMULA: $OCH_2CHCH_3$

GENERAL DESCRIPTION: Colorless liquid; ethereal odor. Also called 1,2-Epoxypropane, propane oxide.

Molecular Wt.: 58.08 Melting Pt.: -104.4° C Boiling Pt.: 33.9° C
Density: (Liquid) 0.8304 (Gas) 2.0 g/l
Vapor Pressure: 400 mm @ 17.8° C 760 mm @ 33.9°C
Flash Pt.: -35°F (T.O.C.) Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower 2.1% Upper 21.5%
Solubility:
Hot Water: Soluble Cold Water: Soluble Ethanol: ∞
Other: ∞ in ether
DOT Classification: Flammable liquid, red label
Coast Guard Classification: Flammable liquid, red label
IATA Classification: Flammable liquid, red label
1 litre max. (passenger), 40 litres(cargo).

## ETHERS

There are many ethers. They will be treated generally in this report.

CHEMICAL FORMULA: R-O-R' where R and R' are the same or different alkyl or aryl groups.

MANUFACTURE: Catalytic dehydration of alcohols is used principally for the production of simple ethers. The Williamson ether synthesis may be used to prepare either simple or mixed ethers (where R is not the same as R').

USES: Ethers are used as solvents for organic reactions and extractions, as plasticizers, as vehicles for other products, as solvents of many organic compounds, as varnish and paint removers, as high boiling point solvents for gums resins waxes in lubricating oils, as insecticides, as cleaning solutions, in leather finishing, as motor fuel additives, in the synthesis of other organic compounds, and in the manufacture of pharmaceuticals, smokeless powder, and rubber cements. Diethyl ether is used as a general anesthesia in surgery.

Dioxane is used as a solvent for cellulose acetate, ethyl cellulose, benzyl cellulose, resins, oils, waxes, oil and spirit-soluble dyes and many other organic and some inorganic compounds.

Propylene oxide is used in the manufacture of alkanolamines, polypropylene glycols, propylene glycol and in paint removers.

**TOXICOLOGY:** The principal hazard in industrial use and handling of the ethers is from inhalation of their vapors. As a class, they do not penetrate the skin in harmful amounts nor are they irritating to the skin. The simpler ethers such as ethyl ether, isopropyl ether, etc., are powerful narcotics which in large doses can cause death.

The Threshold Limit Values (TLV) for dioxane and propylene oxide are:

| | TLV |
|---|---|
| Dioxane | 100 ppm |
| Propylene Oxide | 100 ppm |

The Booz-Allen Ratings are as follows:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSIVE | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Dioxane | 3 | 3 | 2 | 1 | U | U | 2 | 1 | 2 |
| Propylene Oxide | 2 | 2 | 2 | 2 | 1 | U | 2 | 1 | 2 |
| Ethers | 1 | 1 | 1 | 1 | U | U | 2 | 1 | 2 |

**OTHER HAZARDS:** The more volatile ethers, such as ethyl and methyl ether are particularly dangerous fire hazards because of their low ignition and flash points. Peroxides, which form in ethers upon standing pose the additional threat of detonation when an ether is heated after prolonged storage.

**HANDLING, STORAGE, TRANSPORTATION:** Store in a cool well-ventilated area out of the direct rays of the sun and away from heat and open flame and with "NO SMOKING" signs posted. Remove all leaking containers to an isolated well ventilated area or out doors and transfer to other suitable containers. All spills should be flushed away promptly with water.

Before starting a process involving distillation or evaporation a standard test must be passed and the peroxides removed from ethers failing to pass the test.

**DISPOSAL/REUSE:** The following Recommended Provisional Limits are given for the safe disposal of dioxane and propylene oxide:

| Contaminant in Air | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Dioxane | 1.0 ppm (3.6 mg/M$^3$) | 0.01 TLV |
| Propylene Oxide | 1.0 ppm (2.4 mg/M$^3$) | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Dioxane | 18 ppm (mg/l) | Stokinger and Woodward Method |
| Propylene oxide | 12 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES: In all cases it would be better to recycle these materials when possible.

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Controlled burning, at a safe distance, of concentrated waste containing no peroxides. | Satisfactory |
| Destroying filled containers of concentrated peroxide containing waste using rifle fire at 100 feet or more away to perforate the containers. This should be done a safe distance away from habitation and where no harm can come to the surroundings. A blasting cap can be used instead of rifle fire. | Satisfactory |
| Dilute organic waste can be incinerated if the burning temperature is high enough to reduce the waste to $CO_2$ and water. | Satisfactory |
| Incineration of dilute aqueous waste at 1500° F | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Most of the wastes from these materials can be handled and treated at the site of generation. They are not considered to be candidates for National Disposal Sites.

# DIPHENYLAMINE

CHEMICAL FORMULA: $(C_6H_5)_2NH$,

GENERAL DESCRIPTION: Colorless crystals with a floral odor. Also called N - phenylaniline, anilinobenzene.
Molecular Wt.: 169.24 Melting Pt.: 52.9°C Boiling Pt.: 302°C
Density: (Solid) 1.16 g/cc @ 20°C (Gas) 5.82 g/l
Vapor Pressure: 1 mm @ 108.3°C
Flash Pt.: 307°F (C.C.) Autoignition Temperature: 846°F
Explosive Limits in Air (%): Lower ________ Upper ________
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Soluble
Other: Freely soluble in propyl alcohol, benzene, ether, glacial acetic acid, carbon disulfide.
DOT Classification: ________
Coast Guard Classification: ________

MANUFACTURE: Produced by heating aniline with aniline hydrochloride at 210 to 240°C. American Cyanamide and E.I. DuPont de Nemours operate commercial diphenylamine manufacturing facilities.

USES: As a rubber antioxidant, as an intermediate for pharmaceuticals, as an insecticide when fused with sulfur, as a stabilizer for explosives and in the preparation of azo dyes.

TOXICOLOGY: Diphenyl amine is highly toxic when ingested, inhaled or absorbed through the skin. It may be inhaled as the dust or vapor and is irritating to the mucous membranes. Symptoms of diphenylamine poisoning are bladder trouble, tachycardia, hypertension and skin trouble. The Threshold Limit Value (TLV) for diphenyl amine is 10 mg/M$^3$.

The Boss-Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 1 | 2 | 0 | 0 | 3 | 1 | 1 |

OTHER HAZARDS: Diphenyl amine emits highly toxic fumes when heated to decomposition.

HANDLING, STORAGE, TRANSPORTATION: Protective clothing, safety glasses, and respirators should be worn when handling diphenylamine if dust exposure is possible. Direct skin contact should be avoided.

Bulk diphenylamine may be stored in steel equipment for extended periods provided the temperature is kept below 65°C. Prolonged storage at temperatures above 65°C may cause discoloration.

Diphenylamine is shipped in polypropylene lined paper bags, and 8,000 to 10,000 gallon tank cars. No labels are required.

DISPOSAL/REUSE: Aqueous waste streams are not associated with the manufacture of diphenylamine. The toxicity of the material and byproducts of disposal must be considered when disposing of organic diphenylamine waste streams. The Recommended Provisional Limits for releasing diphenylamine into the environment are as follows:

| Diphenylamine as a Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | $0.1\ mg/M^3$ | 0.01 TLV |
| Water and Soil | 0.5 ppm (mg/l) | Stokinger and Woodward Method. |

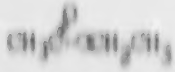
EVALUATION OF WASTE MANAGEMENT: Diphenylamine waste will usually be found in low concentrations in organic waste streams and rarely as concentrated waste.

| METHODS OF DISPOSAL | EVALUATION |
|---|---|
| CONCENTRATED WASTE | |
| Recycling and purification | Best choice when possible |
| Controlled incineration with scrubbers and/or thermal catalytic devices for the effluent gases | Satisfactory |
| Land burial | Satisfactory if the site is acceptable from a geologic and groundwater hydrology point of view and meets California Class 1 landfill requirements. |
| DILUTE ORGANIC WASTE STREAM | |
| Incineration | Satisfactory |
| Plant landfills | Satisfactory if the site is acceptable from a geologic and groundwater hydrology point of view and meets California Class 1 landfill requirements. |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Diphenylamine can be adequately treated at the point of generation and as a waste stream constituent is not considered to be a candidate for National Disposal Sites.

## ESTERS
## (ETHYL ACETATE, METHYL ACETATE, METHYL METHACRYLATE, VINYL ACETATE)

### ETHYL ACETATE

CHEMICAL FORMULA: 
$CH_3\overset{O}{C}-OCH_2CH_3$

GENERAL DESCRIPTION: Colorless flammable liquid. IUC Name: Ethyl ethanoate. Also called acetic ester.
Molecular Wt.: 88.10 Melting Pt.: -83.6°C Boiling Pt.: 77.15°C
Density: (Liquid) 0.8946 @ 25°C (Gas) 3.04 g/l
Vapor Pressure: 100 mm @ 27.0°C
Flash Pt.: 24° F Autoignition Temperature: 800°F
Explosive Limits in Air (Wt%): Lower 2.5% Upper 9%
Solubility:
Hot Water: Slightly Cold Water: Slightly Ethanol: Miscible
Other: Acetone, chloroform, ether
DOT Classification: Flammable, red label
Coast Guard Classification: Red label

MANUFACTURE: The most common method is the direct reaction of acetic acid with ethanol.

### METHYL ACETATE

CHEMICAL FORMULA:
$CH_3-\overset{O}{C}-OCH_3$

GENERAL DESCRIPTION: Colorless, Flammable liquid.
Molecular Wt.: 74.08 Melting Pt.: -98.7°C Boiling Pt.: 57.8°C
Density: (Liquid) 0.9274 g/cc @ 25° C (Gas) 2.55 g/l
Vapor Pressure: 100 mm @ 9.4°C
Flash Pt.: 14° F Autoignition Temperature: 935°F
Explosive Limits in Air (Wt%): Lower 3.1% Upper 16%
Solubility:
Hot Water: Soluble Cold Water: Soluble Ethanol: Miscible
Other: Ether
DOT Classification: Flammable, red label
Coast Guard Classification: Red label

MANUFACTURE: The direct reaction of acetic acid with methanol.

## METHYL METHACRYLATE

CHEMICAL FORMULA:
$CH_2=\overset{CH_3}{C}-\overset{O}{\overset{\|}{C}}-OCH_3$

GENERAL DESCRIPTION: Colorless flammable liquid. IUC Name: Methyl 2-methylpropenoate.

Molecular Wt.: 100.11 Melting Pt.: -50°C Boiling Pt.: 101.0°C
Density: (Liquid) 0.936 g/cc @ 20°C (Gas) 3.45 g/l
Vapor Pressure: 40 mm @ 25.5°C
Flash Pt.: 50° F (O.C.) Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower 2.1% Upper 12.5%
Solubility:
Hot Water: ______ Cold Water: ______ Ethanol: ______
Other: ______
DOT Classification: Flammable, red label
Coast Guard Classification: ______
MANUFACTURE: Reaction of carbon monoxide, acetylene and methanol.

## VINYL ACETATE

CHEMICAL FORMULA:
$CH_3-\overset{O}{\overset{\|}{C}}-OCH=CH_2$

GENERAL DESCRIPTION: Colorless flammable liquid. IUC Name: Ethenyl ethanoate.
Molecular Wt.: 86.09 Melting Pt.: -100.2°C Boiling Pt.: 73°C
Density: (Liquid) 0.9335 @ 20°C (Gas) 3.0 g/l
Vapor Pressure: 100 mm @ 21.5° C
Flash Pt.: 18° F Autoignition Temperature: 800°F
Explosive Limits in Air (Wt%): Lower 2.6% Upper 13.4%
Solubility:
Hot Water: Slightly Cold Water: Slightly Ethanol: Miscible
Other: Ether
DOT Classification: Flammable, red label
Coast Guard Classification: Red label

MANUFACTURE: By the reaction of acetic acid with acetylene.

USES: Esters are used as solvents, plasticizers, resins plastics and coatings, lubricants, and in lacquers, paints, perfumes, flavors, cosmetics, soap and medicine.

TOXICOLOGY: Relatively non-toxic. Irritating to the mucous membranes, particularly the eyes, gums and respiratory passages. Prolonged contact can cause conjunctival irritation and corneal clouding. Mildly narcotic. Ethyl acetate can produce secondary anemia, leucocytosis and cloudy swelling and fatty degeneration of the viscera.

The Threshold Limit Values (TLV) and Maximum Allowable Concentrations (MAC) are:

| Material | TLV<br>ppm | TLV<br>mg/m$^3$ | MAC<br>ppm |
|---|---|---|---|
| Ethyl Acetate | 400 | 1400 | 400 |
| Methyl Acetate | 200 | 610 | 200 |
| Methyl Methacrylate | 100 | 410 | - |
| Vinyl Acetate | 10 | 30 | - |

The Booz-Allen Ratings for these compounds are:

| COMPOUND | HUMAN<br>Air | HUMAN<br>Water | HUMAN<br>Land | ECOLOGICAL<br>Air | ECOLOGICAL<br>Water | ECOLOGICAL<br>Land | EXPLOSIVE<br>Air | EXPLOSIVE<br>Water | EXPLOSIVE<br>Land |
|---|---|---|---|---|---|---|---|---|---|
| Ethyl Acetate | 1 | 2 | 1 | 1 | 1 | U | 2 | 1 | 2 |
| Methyl Acetate | 2 | 2 | 1 | 1 | 1 | U | 2 | 1 | 1 |
| Methyl Methacrylate | 2 | 1 | 2 | U | 2 | U | 2 | 1 | 1 |
| Vinyl Acetate | 1 | 1 | 1 | 3 | 3 | U | 2 | 1 | 1 |

OTHER HAZARDS: These esters are flammable and in the presence of oxygen or other polymerization initiator, acrylate esters can polymerize violently.

HANDLING, STORAGE, TRANSPORTATION: Handle in a well-ventilated area. Wear protective clothing and respirators when contact is likely. In case of contact, remove clothing and wash the skin thoroughly with soap and water.

DISPOSAL/REUSE: Most of these materials are not recoverable, therefore many processes result in dilute ester waste streams with high chemical and biological oxygen demand. They can be treated on site or discharged into the municipal sewers.

Recommended Provisional Limits for release of these materials into the environment are:

| Contaminant in Air | Provisional Limits | | Basis fo Recommendation |
|---|---|---|---|
| | ppm | mg/M³ | |
| Ethyl Acetate | 4.0 | 14 | 0.01 TLV |
| Methyl Acetate | 2.0 | 6.1 | 0.01 TLV |
| Methyl MEthacrylate | 1.0 | 4.1 | 0.01 TLV |
| Vinyl Acetate | 0.1 | 0.3 | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limits ppm (mg/l) | Basis for Recommendation |
|---|---|---|
| Ethyl Acetate | 70.0 | Stokinger and Woodward Method |
| Methyl Acetate | 30.5 | Stokinger and Woodward Method |

| Contaminant in Water and Soil | Provisional Limits ppm or (mg/l) | Basis for Recommendation |
|---|---|---|
| Methyl Methacrylate | 20.5 | Stokinger and Woodward Method |
| Vinyl Acetate | 1.5 | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

Recycling is the best practice when possible.

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Discharge to municipal sewers | Best method if the discharge is uniform. |
| Incineration | Satisfactory |
| Treatment to reduce chemical and biological oxygen demand | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITE:

Municipal and industrial methods of disposal are adequate. These materials are not judged to be candidates for National Disposal Sites.

# ETHYL DISULFIDE

CHEMICAL FORMULA: $C_2H_5SSC_2H_5$

GENERAL DESCRIPTION: Colorless oily liquid. IUC Name: Ethyldithioethane. Also called diethyl disulfide.

Molecular Wt.: 122.2 Melting Pt.: Boiling Pt.: 154°C
Density: (Liquid) 0.99267 g/cc @ 20°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Water: Very slightly soluble Ethanol Infinitely soluble
Other: Infinitely soluble in ether
DOT Classification:
Coast Guard Classification:

TOXICOLOGY: Animal experiments suggest that the alkyl disulfides are dangerous and may cause hemolytic anemia. They may also produce dermatitis.

OTHER HAZARDS: Dangerous when heated to decomposition it emits highly toxic fumes of sulfides. It probably reacts violently with powerful oxidizers and is probably a moderate fire hazard.

HANDLING, STORAGE, TRANSPORTATION: Store in a cool, dry well ventilated area, away from heat and open flames. Avoid breathing fumes.

## FERRIC CHLORIDE

CHEMICAL FORMULA: $FeCl_3$

GENERAL DESCRIPTION: Black-brown solid.
Molecular Wt.: 162.2 Melting Pt.: 282°C Boiling Pt.: 315°C
Density: (Solid) 2.804 g/cc @ 11°F (Gas)
Vapor Pressure: 1 mm @ 194°C
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 535.7 g/100 ml @ 100°C Cold Water: 74.4 g/100 ml @ 0°C
Ethanol: Very soluble. Other: Very soluble in ether,
63 g/100 ml in acetone @ 18°C

CHEMICAL FORMULA: $FeCl_3 \cdot 6H_2O$

GENERAL DESCRIPTION: Brown-yellow, very deliquescent, crystalline solid.
Molecular Wt.: 270.32 Melting Pt.: 37°C Boiling Pt.: 280-285°C
Density: (Solid) (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Infinitely soluble Cold Water: 91.9 g/100 ml @ 20°C
Ethanol: Soluble Other: Soluble in ether
DOT Classification:
Coast Guard Classification:
IATA Classification: Other restricted articles, class B, no label required
12 kilograms (passenger), 45 kilograms (cargo)

OTHER HAZARDS: Dangerous. When heated to decomposition, it emits highly toxic fumes of hydrochloric acid. It will react with water to produce toxic fumes of hydrochloric acid. It will react with water to produce toxic and corrosive fumes.

HANDLING, STORAGE, TRANSPORTATION: Store in a cool, dry place away from heat and flames.

# FERROUS CHLORIDE

CHEMICAL FORMULA: $Fe\,Cl_2$

GENERAL DESCRIPTION: Green to yellow deliquescent crystalline solid. Also called Lawrencite.

Molecular Wt.: 126.8 Melting Pt.: 670-674°C Boiling Pt.: 1026°C
Density: (Solid) 2.98 g/cc (Gas) ______
Vapor Pressure: 10 mm @ 700°C
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: 105.7 g/100 ml @100°C Cold Water: 64.4 g/100 ml @10°C
Ethanol: 100 g/100 ml Other: Soluble in acetone, insoluble in ether.

CHEMICAL FORMULA: $FeCl_2 \cdot 4H_2O$

GENERAL DESCRIPTION: Blue green deliquescent crystalline solid.

Molecular Wt.: 198.81 Melting Pt.: ______ Boiling Pt.: ______
Density: (Solid) 1.93 g/cc (Gas) ______
Vapor Pressure: ______
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: 415.15 g/100 ml @ 100°C Cold Water: 160.1 g/100 ml @ 10°C
Ethanol: Soluble Other: ______
DOT Classification: ______
Coast Guard Classification: ______

OTHER HAZARDS: When heated to decomposition, it emits highly toxic fumes of hydrochloric acid.

# FERROUS SULFATE

CHEMICAL FORMULA: $FeSO_4 \cdot 7H_2O$

GENERAL DESCRIPTION: Blue to green crystalline solid. Also called iron sulfate, copperas and green vitriol

Molecular Wt.: 278.01 Melting Pt.: 64°C-6H$_2$O Boiling Pt.: 300°C-7H$_2$O

Density: (Solid) 1.898 g/cc @ 20°C (Gas)

Vapor Pressure:

Flash Pt.: Autoignition Temperature:

Explosive Limits in Air (Wt%): Lower Upper

Solubility:

Hot Water: 48.6 g/100 ml @ 50°C Cold Water: 15.65 g/100 ml

Ethanol: Insoluble Other:

DOT Classification:

Coast Guard Classification:

MANUFACTURE: As a by-product from production, direct reaction between dilute sulfuric acid and iron, and oxidation of pyrites in air followed by leaching and treatment with scrap iron.

USES: Water purification, source for other iron salts and oxides, fertilizer, food additive, writing inks, pigments, medicine, deodorizer, metallurgy, aluminum etching and in wood preservative compositions.

TOXICOLOGY: Ferrous sulfate has caused death when excessive quantities have been ingested. The lowest lethal dose was 0.5 gm. The Threshold Limit Value for $FeSO_4$ is 1 mg/M$^3$ as Fe.

The Booz-Allen Ratings are:

| HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 1 | 1 | 1 | 2 | 3 | 0 | 1 | 1 | 1 |

OTHER HAZARDS: Ferrous sulfate will corrode iron and most steels. It will hydrolyze to produce an acid solution.

HANDLING, STORAGE, TRANSPORTATION: Ferrous sulfate etches iron and aluminum. Other than protection from moisture, no special care is needed.

DISPOSAL/REUSE: If the quality and quantity of the waste makes it economically feasible, it can be reprocessed for reuse. For disposal into the environment, the following Provisional Limits are recommended:

| Ferrous Sulfate as a Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.01 mg/M$^3$ as Fe | 0.01 TLV for Fe |
| Water and Soil | 0.03 ppm as Fe | Drinking Water Standard |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Dissolve in a large excess of water and treat with a slight excess of soda ash and slaked lime. Let stand for 24 hours. The liquid is decanted into another container and neutralized with HCl. The liquid is diluted and discharged into a sewer or stream. The sludge is added to a landfill. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Ferrous sulfate waste can be adequately treated at the point of generation and discharged into municipal sewers or streams and are not considered to be candidate waste stream constituents for National Disposal Sites.

## FORMIC ACID

CHEMICAL FORMULA:
$H-\overset{O}{\overset{\|}{C}}-OH$

GENERAL DESCRIPTION: Colorless corrosive liquid. IUC Name: Methanoic acid.
Molecular Wt.: 46.03 Melting Pt.: 8.2°C Boiling Pt.: 100.8°C
Density: (Liquid) 1.2267 g/cc @ 15° C (Gas) 1.59 g/l
Vapor Pressure: 40 mm @ 24° C
Flash Pt.: 156° F (O.C.) Autoignition Temperature: 1114°F
Explosive Limits in Air (Wt%): Lower 18% Upper 57%
Solubility: (90% Solution) (90% Solution)
Hot Water: Miscible Cold Water: Miscible Ethanol: Miscible
Other: Ether
DOT Classification: Corrosive, white label
Coast Guard Classification: White label

MANUFACTURE: Reaction of sodium hydroxide and carbon monoxide to produce sodium formate which is then acidized to the acid.

USES: Textile dyeing and finishing. (50%) Chemical synthesis and in the leather industry.

TOXICOLOGY: Vapor causes irritation of the eyes and upper respiratory tract and skin lesions characterized by cracking and fissuring of the skin. Ingestion causes a burning pain in the stomach followed by nausea and vomiting.

The Threshold Limit Value (TLV) for formic acid is: 5 ppm or 9 mg/M$^3$.

The Booz-Allen Ratings for formic acid are:

| HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 2 | 2 | 1 | 1 | 2 | 1 | 1 |

HANDLING, STORAGE, TRANSPORTATION: Formic acid should be handled in a well ventilated area. Protective clothing and respirators are recommended. In case of skin contact, all contaminated clothing should be removed and the skin washed with soap and water.

DISPOSAL/REUSE: Any unused material is recycled. Dilute waste streams can be treated on site or discharged to municipal sewers after pH adjustment.

Recommended Provisional Limits for formic acid are:

| Formic Acid as a Contaminant in | Provisional Limit ppm | mg/M³ | Basis for Recommendation |
|---|---|---|---|
| Air | 0.05 | 0.09 | 0.01 TLV |
| Water and Soil | 0.45 | | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Recycling | Best choice when possible |
| Treatment of waste to reduce chemical and biological oxygen demand and discharge into municipal sewers | Satisfactory |
| Incineration | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES:

Formic acid waste can be satisfactorily treated by municipal and industrial methods and therefore is not considered a candidate waste stream constituent for National Disposal Sites.

## GOLD CHLORIDE

### AURIC CHLORIDE

CHEMICAL FORMULA: $AuCl_3$

GENERAL DESCRIPTION: Claret red crystalline solid. Also called gold chloride.

Molecular Wt.: 303.57 Melting Pt.: 254°C d Boiling Pt.: 265°C sub-
Density: (Solid) 3.9 g/cc (Gas) /liter
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Very soluble Cold Water: 68 gm/100 ml
Ethanol: Soluble Other: Soluble in ether, slightly soluble in $NH_3$, insoluble in carbon disulfide.
DOT Classification:
Coast Guard Classification:

### AUROUS CHLORIDE

CHEMICAL FORMULA: $AuCl$

GENERAL DESCRIPTION: Yellow crystalline solid.

Molecular Wt.: 232.44 Melting Pt.: 170°C decomposes to $AuCl_3$
Density: (Solid) 7.4 g/cc Boiling Pt.: 289.5°C decomposes
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: decomposes Cold Water: decomposes, very slightly
Ethanol: Other: Soluble in HCl and HBr
DOT Classification:
Coast Guard Classification:

TOXICOLOGY: Salts of gold may cause urticaria (hives), itching, purpura and other skin rashes, some of which may be severe. They may also cause damage to the blood forming organs resulting in aplastic anemia. The liver, kidneys and nervous system may also be affected.

OTHER HAZARDS: Chlorides, when heated to decomposition or on contact with acid or acid fumes, evolve highly toxic chloride fumes.

# HEXAMETHYLENEDIAMINE AND UREA

## HEXAMETHYLENEDIAMINE

CHEMICAL FORMULA: $H_2N-CH_2-CH_2-CH_2-CH_2-CH_2CH_2-NH_2$

GENERAL DESCRIPTION: Colorless crystaline solid. IUC Name: 1,6-Hexanediamine.

Molecular Wt.: 116.21 Melting Pt.: 39-40°C Boiling Pt.: 196°C
Density: (Liquid) (Gas) Sublimes at 204-205°C
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Vol%): Lower Upper
Solubility:
Hot Water: Cold Water: Very Ethanol: Slightly
Other: Slightly soluble in benzene
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Displacement of a reactive functional group from the aliphatic compound. By the following reaction: $CH_2=CH-CH=CH_2 \xrightarrow{Cl_2} ClCH_2-CH=CH-CH_2Cl \xrightarrow{NaCN} NC-CH_2-CH=CH-CH_2-CN \xrightarrow{H_2} NH_2CH_2CH_2-CH_2-CH_2-CH_2-CH_2-NH_2$ and several other processes.

USES: In the production of nylons 6, 6 and 6,10.

## UREA

CHEMICAL FORMULA: $H_2N-\overset{O}{\overset{\|}{C}}-NH_2$

GENERAL DESCRIPTION: Colorless crystalline solid. Also called carbamide, carbonyl diamide.

Molecular Wt.: 60.06 Melting Pt.: 132.7°C Boiling Pt.: Decomposes
Density: (Liquid) 1.335 gm/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air: Slightly dangerous when heated to decomposition.
Solubility:
Hot Water: Very soluble Cold Water: Soluble Ethanol: Soluble
Other: Slightly soluble in ether, soluble in methanol and glycerol
DOT Classification: None
Coast Guard Classification:

MANUFACTURE: By the reaction of carbon dioxide with ammonia at 150-200°C.

and 150-300 atm. pressure.

USES: Used as a fertilizer, cattle feed and resins.

TOXICOLOGY: Not particularly systematically toxic. Amines can cause corrosive and damaging effect on tissue. Repeated exposure to diamines can cause hypersensitivity, dermatitis and in some people allergenic and asthmatic reactions. Chronic ingestion of diamines can cause liver and kidney damage.

The Threshold Limit Values for these compounds are not available.

The Hesse-Allen Ratings for these compounds are:

| | HUMAN | | | ECOLOGICAL | | | AESTHETIC | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Hexamethylene Diamine | 2 | 2 | 2 | 0 | 0 | 0 | 1 | 1 | 1 |
| Urea | 1 | 1 | 1 | 0 | 1 | 0 | 1 | 1 | 1 |

OTHER HAZARDS: When heated to decomposition, aliphatic amines may emit noxious, irritating and toxic fumes. Will react with some compounds to form potentially explosive mixture. Urea has no hazards.

HANDLING, STORAGE AND TRANSPORTATION: Handle in a well ventilated area. Use protective clothing and respirators where necessary. Store in a cool, dry well ventilated place.

DISPOSAL/REUSE: In the manufacture of urea close to 100 percent of all raw materials and reaction products are used as feed and fertilizer. Heavy bottoms from purification of amines are disposed of by incineration, landfill, deep well injection or is processed to reduce the biological and chemical oxygen demand. Some nitrogen containing materials are produced in dilute waste streams in the manufacture of amines. These are usually discharged into sewers or rivers with out pretreatment or by deep well disposal.

The Recommended Provisional Limits for release into the environment are:

| Contaminant in Air | Provisional Limit<br>ppm | <br>mg/M³ | Basis for Recommendation |
|---|---|---|---|
| Hexamethylenediamine | - | 0.04 | Based on similar compounds. |
| Urea | - | 0.06 | Based on similar compounds |

| Contaminant in Soil and Water | Provisional Limit ppm or mg/l | Basis for Recommendation |
|---|---|---|
| Hexamethylenediamine | 0.20 | Based on similar compounds |
| Urea | 0.30 | Based on similar compounds |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Reformulation of products to reduce environmental impact, when necessary | Satisfactory |
| Treatment of waste water and water soluble by-products to reduce biological and chemical oxygen demand at manufacturing site or by municipal waste treatment system. | Satisfactory |
| Incineration of badly contaminated amines with scrubber | Satisfactory |
| Landfill of residue and sludges obtained during manufacture or use. | Less satisfactory than incineration due to long term threat to underground water. |

APPLICABILITY TO NATIONAL DISPOSAL SITES: These materials are not recommended for disposal at National Disposal Sites, since they can be adequately handled by industrial methods.

## 1-HEXANOL

CHEMICAL FORMULA: $CH_3(CH_2)_4CH_2OH$

GENERAL DESCRIPTION: Colorless liquid. Also called n-hexyl alcohol and amyl carbinol

Molecular Wt.: 102.17 Melting Pt.: -51.6°C Boiling Pt.: 157.2°C
Density: (Liquid) 0.8186 g/cc @ 20°C (Gas) 3.52 g/l
Vapor Pressure: 1 mm @ 24.4°C
Flash Pt.: 145°F Autoignition Temperature:
Explosive Limits in Air (Vol%): Lower Upper
Solubility:
Hot Water: Insoluble Cold Water: Insoluble Ethanol: Infinitely /Soluble
Other: Infinitely soluble in ether
DOT Classification:
Coast Guard Classification:

TOXICOLOGY: Highly toxic.

OTHER HAZARDS: Moderate fire hazard. When exposed to heat or flame it can react with oxidizing materials.

HANDLING, STORAGE, TRANSPORTATION: When handling hexanol wear protective equipment to avoid contact. If there is accidental contact, wash the contacted area with soap and water. Remove contaminated clothing and wash before reuse. Store in a cool well ventilated place away from heat and open flame.

# HYDROCHLORIC ACID

CHEMICAL FORMULA: HCl

GENERAL DESCRIPTION: Colorless gas or colorless, poisonous fuming liquid. Also called muriatic acid, chlorohydric acid and hydrogen chloride.

Molecular Wt.: 36.46 Melting Pt.: -114.8°C Boiling Pt.: -84.9°C
Density: (Liquid) ____ (Gas) ____
Vapor Pressure: ____
Flash Pt.: ____ Autoignition Temperature: ____
Explosive Limits in Air (Wt%): Lower ____ Upper ____
Solubility: @ 0°C
Hot Water: 56.1g/100ml@60°C Cold Water: 82.3g/100ml Ethanol: Soluble
Other: ____
DOT Classification: Corrosive liquid, white label (liquid)
Coast Guard Classification: Corrosive liquid, white label (liquid)
MCA Warning Label
IATA Classification: Corrosive liquid, white label,
1 liter (passenger) 5 liters (cargo)
Coast Guard (anhydrous) Classification: Nonflammable gas, green gas label

MANUFACTURE: Hydrochloric acid is produced from four major sources:

(1) as a by product in the chlorination of both the aromatic and aliphatic hydrocarbons;

(2) from the reaction between sulfuric acid and salts of hydrochloric acid;

(3) from the combustion of hydrogen and chlorine;

(4) from the Hargreaves type reactions such as: $4\ NaCl + 2SO_2 + O_2 + H_2O \longrightarrow 2Na_2SO_4 + 4HCl$.

In 1969, 1.8 million tons were produced in the U.S.

USES:

(1) In the manufacture of pharmaceutical hydrochlorides, various inorganic and organic chlorides and chlorine;

(2) In chlorination, isomerization, polymerization and alkylation processes;

(3) as a chemical reagent.

TOXICOLOGY: Hydrochloric acid is strongly corrosive. It is an irritant to the mucous membranes of the eyes and the respiratory tract. On contact concentrated solution causes severe burns; permanent visual damage may occur. Inhalation of the fume causes coughing, choking and inflammation and ulceration of the respiratory tract.

The Threshold Limit Values (TLV) and Lethal Concentrations for $HCl_{(g)}$ are:

| TLV | Lethal Concentration |
|---|---|
| 7 mg/M$^3$ | ih $LC_{Lo}$ : 1000 mg/M$^3$, rabbit |

The Booz Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 1 | 3 | 0 | 2 | 1 | 2 |

OTHER HAZARDS: No other hazards known.

HANDLING, STORAGE, TRANSPORTATION: Corrosive materials such as hydrochloric acid must be handled carefully. Contact with skin and inhalation of the fume must be avoided. It should be kept away from food. Containers should be kept tightly closed.

DISPOSAL/REUSE: Provisional Limit for the safe disposal of hydrochloric acid into the environment are as follows:

| As a Contaminant in | Maximum Exposure Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.07 mg(Vapor)/M$^3$ | 0.01 TLV |
| | Provisional Limit | |
| Water and Soil | 0.15 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Neutralization with soda ash-slaked lime. Discharge after dilution | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Hydrochloric acid as a waste stream constituent is not considered to be a candidate for disposal at National Disposal Sites.

# HYDROGEN CYANIDE

CHEMICAL FORMULA: HCN

GENERAL DESCRIPTION: Colorless poisonous liquid. Faint odor of bitter almonds. Also called hydrocyanic acid and prussic acid.
Molecular Wt.: 27.03 Melting Pt.: -13.2°C Boiling Pt.: 25.7°C
Density: (Liquid) 0.688 g/cc @ 20°C (Gas) 0.969 g/l @ 31°C
Vapor Pressure: 400 mm @ 9.8°C
Flash Pt.: 0°F (CC) Autoignition Temperature: 100°F
Explosive Limits in Air (Wt%): Lower 6% Upper 4[illegible]
Solubility:
Hot Water: Miscible Cold Water: Miscible Ethanol: Miscible
Other: Miscible in ether
DOT Classification: Class "A" poison
Coast Guard Classification: Class "A" poison

MANUFACTURE: HCN is manufactured commercially by six different processes: (1) by treating a cyanide with dilute sulfuric acid; (2) by catalytically reacting ammonia and air with methane or natural gas; (3) by recovery from coke oven gases; (4) decomposition of formamide; (5) from ammonia and hydrocarbons by electrofluid reaction in the presence of a platinum-rhodium catalyst; and (6) by pyrolytic decomposition of residues from beet-sugar molasses.

USES: Used in the manufacture of acrilonitrile, acrylates, adiponitrile, cyanide salts, dyes, fumigants, chelates, rubbers and plastics.

TOXICOLOGY: (Human Toxicity) Hydrogen cyanide and the cyanides are true protoplasmic poisons. They combine in the tissues with enzymes associated with cellular oxidation. They thereby render oxygen unavailable to the tissues, and cause death through asphyxia. This effect lasts only while the cyanide is present; upon its removal, normal function is restored provided death has not already occurred. Hydrocyanic acid can be absorbed through the skin. The Threshold Limit Value (TLV) is 10 ppm in air (11 mg/M3).

The Booz-Allen Ratings are:

| HUMAN | | | BIOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 3 | 3 | U | 3 | 2 | 3 |

(OTHER TOXICITY) Cyanides either as hydrogen cyanide or its salts are often found in industrial aqueous waste streams. Cyanide ion, for the most part, is unaffected by the basic water treatment plant. Many lower animals and fish are able to convert cyanide to the thiocyanate ion which does not inhibit respiratory enzyme activity. A permissible criterion has been recommended of 0.20 mg/l for waste discharged into streams, and a desirable criterion of complete absence from public waters was recommended by the Federal Water Pollution Control Administration Water Quality Committee.

**OTHER HAZARDS:** When HCN is exposed to heat, flame or oxidizing materials, a fire or explosion may occur. Under certain conditions, particularly contact with alkaline materials, HCN can polymerize or decompose explosively. The compressed gas is commonly stabilized by the addition of acids.

**HANDLING, STORAGE, TRANSPORTATION:** Liquid hydrogen cyanide is subject to DOT regulations for the transportation of explosives and other dangerous articles. It is packed in metal cylinders for interstate transportation. The cylinders must have not more than 125 lb water capacity. It is not accepted for shipment by railway express.

Hydrogen cyanide should be stored in bulk, steel storage tanks and these should be kept cool and protected from mechanical injury.

**DISPOSAL/REUSE:** Hydrogen cyanide appears in both aqueous and gaseous waste streams from several operations. Complete removal is difficult. Provisional Limits for public exposure resulting from the disposal of HCN are as follows:

| HCN in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.11 mg/M$^3$ | 0.01 TLV |
| Water and Soil | 0.01 mg/l (as CN) | Drinking Water Standard |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Conversion to cyanate, then to carbon dioxide and ammonia. | Satisfactory |
| Removal from aqueous solution by passing air through the solution, then passing through an alkaline scrubber. | Satisfactory |
| Incineration and passing the effluent through an alkaline scrubber. | Satisfactory |
| By passing air containing HCN through a sodium or potassium hydroxide scrubber. The salts produced are recovered by evaporating the water containing the salts. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: The waste streams containing hydrogen cyanide can be adequately treated at the source of waste generation and therefore are not considered candidates for National Disposal Sites.

# HYDROGEN PEROXIDE

CHEMICAL FORMULA: $H_2O_2$

GENERAL DESCRIPTION: Colorless heavy liquid or at low temperatures a crystalline solid. Also called hydrogen dioxide and T-Stuff.

Molecular Wt.: 34.02 Melting Pt.: -89°C Boiling Pt.: 152.1°C
Density: (Liquid) 1.4389 g/cc 20°C (Gas) ______
Vapor Pressure: 1 mm @ 15.3°C
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: ______ Cold Water: Infinitely Ethanol: ______
Other: ______
DOT Classification: Corrosive liquid, white label
Coast Guard Classification: Corrosive liquid, white label
MCA Warning Label

MANUFACTURE:
(1) autoxidation of anthraquinone;
(2) oxidation of lower secondary alcohol to yield $H_2O_2$ and ketone;
(3) electrolysis through ammonium persulfate.

70,000 tons of $H_2O_2$ were produced in the United States in 1969.

USES:
(1) as a bleaching agent of cotton textiles;
(2) as an oxidizing agent for organic compounds;
(3) as an oxidizing agent for inorganic compounds;
(4) in the manufacture of organic and inorganic peroxides;
(5) in the plastic industry;
(6) in pharmaceutical preparations, mouth washes, dentifrices, sanitary lotions;
(7) as a topical antiseptic;
(8) in rocket propulsions (using 90% solution).

TOXICOLOGY: Hydrogen peroxide is not a toxic material. However, strong solutions can cause burns of the skin and mucous membranes.

The Threshold Limit Value (TLV) for hydrogen peroxide is 1.4 mg/M$^3$.

The Booz-Allen Ratings for $H_2O_2$ (over 52%) are:

| HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 2 | 1 | 0 | 1 | 1 | 1 |

OTHER HAZARDS: Hydrogen peroxide is a powerful oxidizer, particularly the concentrated solution. Heat is generated during hydrogen peroxide decomposition and therefore it is a fire hazard when heated or contacted with flammable materials.

HANDLING, STORAGE, TRANSPORTATION: Powerful oxidizers such as hydrogen peroxide should be kept away from reducing agents or combustible materials. Containers should be kept tightly closed.

DISPOSAL/REUSE: Provisional Limits for the safe disposal of hydrogen peroxide into the environment are as follows.

| $H_2O_2$ as a Contaminant | Maximum Exposure | Basis for Recommendation |
|---|---|---|
| in Air | 0.014 mg/M$^3$ | 0.01 TLV |
| | Provisional Limit | |
| in Water and Soil | 0.07 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Dilution with water to release the oxygen. Then discharge. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Hydrogen peroxide as a waste stream constituent is not considered a candidate for disposal at National Disposal Sites.

# MERCURY AND INORGANIC MERCURY COMPOUNDS
# MERCURY, MERCURIC CHLORIDE, MERCURIC NITRATE,
# MERCURIC SULFATE, MERCURIC DIAMMONIUM CHLORIDE

## MERCURY

CHEMICAL FORMULA: Hg

GENERAL DESCRIPTION: Heavy metallic liquid. Commonly called quick silver. Highly reactive with halogens, hydrogen, sulfide and sulfur

Molecular Wt.: 200.59 Melting Pt.: -38.9°C Boiling Pt.: 356.6°C

Density: (Liquid) 13.594 g/cc @ 20°C (Gas)

Vapor Pressure: 1.2 x10$^{-3}$ @ 20°C; 1 mm @ 126.2°C; 10 mm @ 184°C

Flash Pt.: Autoignition Temperature:

Explosive Limits in Air (Vol%): Lower Upper

Solubility:

Hot Water: Cold Water: 20-30 ppb in Aerated $H_2O$ Ethanol:

Other:

DOT Classification: Poison B

Coast Guard Classification:

## MERCURIC CHLORIDE

CHEMICAL FORMULA: $HgCl_2$

GENERAL DESCRIPTION: White crystals or powder. Also called corrosive sublimate. Highly toxic.

Molecular Wt.: 271.50 Melting Pt.: 276°C Boiling Pt.: 302°C

Density: (Solid) 5.440 g/cc @ 25°C (Gas)

Vapor Pressure: 1 mm @ 136.2°C; 10 mm @ 180.2°C; 100 mm @ 237°C

Flash Pt.: Autoignition Temperature:

Explosive Limits in Air (Vol%): Lower Upper

Solubility:

Hot Water: 48 g/100 cc @ 100°C Cold Water: 6.9 g/100 cc @ 20°C

Ethanol: Soluble Other:

DOT Classification: Poison B

Coast Guard Classification:

## MERCURIC NITRATE

CHEMICAL FORMULA: $Hg(NO_3)_2 \cdot 1/2\ H_2O$

GENERAL DESCRIPTION: White yellowish deliquescent powder. Highly toxic.

Molecular Wt.: 324.61 Melting Pt.: 79°C Boiling Pt.: Decomposes
Density: (Solid) 4.39 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Decomposes Cold Water: Very soluble
Ethanol: Insoluble Other: Soluble in $HNO_3$, $NH_3$, acetone.
Also has formula $Hg(NO_3)_2 \cdot H_2O$
Molecular Wt: 342.61 Colorless crystal or white powder, deliquescent.
Solubility:
Hot Water: Cold Water: Soluble
Ethanol: Insoluble Other: soluble in $HNO_3$
Coast Guard Classification:
DOT Classification:

## MERCURIC SULFATE

CHEMICAL FORMULA: $HgSO_4$

GENERAL DESCRIPTION: White crystalline powder.
Molecular Wt.: 296.65 Melting Pt.: Decomposes Boiling Pt.:
Density: (Solid) 6.47 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: --- Cold Water: Decomposes
Ethanol: Insoluble Other: Soluble in acids.
DOT Classification: Poison B
Coast Guard Classification: Poison B

## MERCURIC DIAMMONIUM CHLORIDE

CHEMICAL FORMULA: $Hg(NH_3)_2Cl_2$

GENERAL DESCRIPTION: Rhombododecahedral crystal.
Molecular Wt.: 305.56 Melting Pt.: 300°C Boiling Pt.:
Density: (Solid) (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Decomposes Cold Water: Insoluble
Ethanol: Other:

DOT Classification: Poison B
Coast Guard Classification:

MANUFACTURE: Mercury: Most commonly by roasting cinnabar (mercuric sulfide) in either mechanical furnaces or retorts to volatize the mercury, followed by condensation of the vapor. Leaching with either sodium hypochlorite or sodium sulfide. The major U.S. producers of mercury include the following:

DeCoursey Mountain Mining Company; Anchorage, Alaska
Harold Biaggini; Atascadero, California
CCC Minerals Corp.; Denver, Colorado
New Idria Mining and Chemical Co.; Guerneville, California
Holly Minerals Corp.; Albuquerque, New Mexico
Rare Metals Corp. of America; Salt Lake City, Utah
Cordero Mining Co.; Palo Alto, California
Arentz-Comstock Mining Venture; Salt Lake City, Utah
Bonanza Oil and Mining Corp.; Sutherlin, Oregon

Mercuric Chloride: Produced commercially by the direct chlorination of mercury. Older processes, based on the reaction between mercurous sulfate and sodium chloride, are no longer extensively practiced in the United States.

Mercuric Nitrate: Made by dissolving mercury in an excess of hot concentrated nitric acid, followed by cooling to crystallize the hydrate.

Mercuric Sulfate: Prepared by reacting a paste of freshly precipitated and washed yellow mercuric oxide with the calculated amount of sulfuric acid, followed by filtration of the white crystalline sulfate on a nutsch and subsequent drying. It may also be prepared by heating mercury with an excess of sulfuric acid; the formation is favored at high temperatures.

Mercuric Diammonium Chloride: Made by dissolving mercuric chloride in a strong aqueous solution of ammonium chloride, and adding ammonia solution. It may also be prepared by treating finely powdered dry mercuric chloride with anhydrous ammonia vapor. The major U.S. producers of inorganic mercury chemicals include the following:

Allied Chemical Corp.; Specialty Chemicals Division; Morristown, New Jersey
City Chemical Corp.; Jersey City, New Jersey
Mallinckrodt Chemical Works, Industrial Chemical Division; Jersey City, New Jersey
Merck & Co., Inc., Merck Chemical Division, Rahway, New Jersey
Troy Chemical Corp.; Newark, New Jersey
Ventron Corp., Alfa Products; Beverly, Massachusetts
Ventron Corp., Chemicals Division; Beverly, Massachusetts

USES: The major use of mercury is as a cathode in the electrolytic preparation of chlorine and caustic soda. Large quantities of mercury are also used in electrical apparatus, in industrial and control instruments, and in general laboratory applications. These potentially recyclable uses of mercury are for fluorescent and high pressure mercury lamps, arc rectifiers, mercury battery cells, switches, thermometers, barometers, diffusion pumps, vacuum gages, and as a vibration damper.

The largest dissipative use of mercury is for mildewproofing paints. (Mercury is no longer used in antifouling paints). Mercury compounds are also widely used in agriculture as a result of their broad antifungal capabilities, for catalytic purposes, and formulated into many of the over-the-counter cosmetics (such as creams and lotions, hair preparations, and facial make-up) and patent medicines (antacids, astringents, eye drops, laxatives, nasal sprays, skin antiseptics, contraceptives). Mercury is used in dental amalgams, and to a decreasing extent, for the control of slime in the paper and pulp mills.

Individual figures of mercury consumption by use from 1967 to 1971 have been compiled by the Bureau of Mines (Table 19), and indicate that declining levels of consumption were noted for mercury uses in agriculture, catalysts, electrolytic preparation of chlorine and caustic soda, installation and expansion of chlor-alkali plants, and paper and pulp manufacture (Table 19).

An estimate of the current and future use pattern of mercury over the next few years has also been presented (Table 20). Of the eleven major categories represented, decreasing demands are forecasted in five, including agriculture, electrolytic preparation of chlorine and soda, installation and expansion of chlor-alkali plants, paints, and paper and pulp manufacture. The other six major uses of mercury are expected to continue at about the same level. These predicted trends in mercury consumption also point toward the same direction where future efforts of mercury recovery and pollution control should be aimed.

Of the four inorganic mercury compounds included in this report, mercuric diammonium chloride is of no commercial significance; whereas mercuric chloride is one of the most industrially important mercury compounds, as a catalyst in vinyl chloride manufacture and other organic reactions, and as a preservative for wood. In agriculture, it is used either as a dust or spray for the control of certain fungus diseases on seeds. Solutions of mercuric chloride are used medicinally as an antiseptic, and in photography to intensify negatives.

Mercuric nitrate is used in the preparation of other mercury compounds, and in particular, mercury fulminate. It is also used in the manufacture of felt, and for the destruction of phylloxera.

Mercuric sulfate is mainly used as an electrolyte for primary batteries. Aside from its occasional use as a catalyst, mercuric sulfate has been employed in conjunction with sodium chloride to extract gold and silver from roasted pyrites.

Table 15. MERCURY CONSUMED IN UNITED STATES BY USES

| Use | Consumption, Flasks | | | | |
|---|---|---|---|---|---|
| | 1967 | 1968 | 1969 | 1970 | 1971 |
| Agriculture (includes fungicides and bactericides for industrial purposes) | 3,732 | 3,430 | 2,689 | 1,812 | 1,477 |
| Amalgamation | 229 | 267 | 195 | 226 | * |
| Catalysts | 2,489 | 1,914 | 2,958 | 2,061 | 1,141 |
| Dental preparations | 1,359 | 2,089 | 3,483 | 1,796 | 2,387 |
| Electrical apparatus | 14,610 | 17,484 | 18,650 | 15,789 | 16,938 |
| Electrolytic preparation of chlorine & caustic soda | 14,306 | 17,458 | 20,720 | 14,977 | 12,262 |
| General laboratory uses | 1,133 | 2,286 | 2,042 | 1,513 | 1,809 |
| Industrial & control instruments | 3,865 | 3,935 | 6,982 | 4,035 | 4,071 |
| Paint: | | | | | |
| Antifouling | 152 | 392 | 244 | 193 | 424 |
| Mildew proofing | 7,026 | 10,174 | 9,486 | 8,771 | 8,241 |
| Paper & pulp manufacture | 446 | 427 | 588 | 226 | * |
| Pharmaceuticals | 283 | 424 | 724 | 571 | 682 |
| Redistilled‡ | 7,129 | 8,247 | — | — | — |
| Other+ | 12,568 | 7,945 | 9,689 | 6,521 | 2,330 |
| Total known uses | 69,517 | 75,422 | 78,048 | 58,554 | 52,472 |
| Total uses unknown | — | — | 1,056 | 2,936 | 3 |
| Grand total | 69,517 | 75,422 | 79,104 | 61,490 | 52,475 |

* Withheld to avoid disclosing individual company confidential data; included with "Other".

‡ "Redistilled" used in industrial instruments, dental preparations, and electrical apparatus. Figures for the Redistilled category are not available after 1968, but have probably been broken down and added to the figures of the individual use categories.

+ "Other" includes mercury used for installation and expansion of chlor-alkali plants.

Table 19. TRENDS IN USES OF MERCURY OVER THE PERIOD 1967 to 1971

| Use | 1971 Consumption<br>Flasks | <br>Percent of Total |
|---|---|---|
| **Decreasing Level of Consumption** | | |
| Agriculture | 1,477 | 2.8 |
| Catalysts | 1,141 | 2.2 |
| Electrolytic Preparation of Chlorine and Soda | 12,262 | 23.4 |
| Other Uses* | 2,300 | 4.4 |
| Subtotal | 17,180 | 32.8 |
| **No Significant Changes in Consumption** | | |
| Dental Preparations | 2,387 | 4.5 |
| Electrical Apparatus | 16,938 | 32.3 |
| General Laboratory Uses | 1,809 | 3.4 |
| Industrial and Control Instruments | 4,871 | 9.3 |
| Paints | 8,605 | 16.4 |
| Pharmaceuticals | 682 | 1.3 |
| Subtotal | 35,292 | 67.2 |
| Grand total | 52,472 | 100.0 |

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*Other uses include mercury used for installation and expansion of chlor-alkali plants, amalgamation, and in paper and pulp manufacture.

Table 20. ESTIMATED TRENDS IN CONSUMPTION OF MERCURY

| Use | Estimated Mercury Consumption, Flasks 1971 | Estimated Mercury Consumption, Flasks 1974-1975 |
|---|---|---|
| Agriculture | 1,477 | 0 |
| Catalysts | 1,141 | 1,141 |
| Dental Applications | 2,387 | 2,387 |
| Electrical Apparatus | 16,938 | 16,938 |
| Electrolytic Preparation of Chlorine and Soda | 12,262 | 679* |
| General Laboratory Use | 1,809 | 1,809 |
| Industrial and Control Instruments | 4,871 | 4,871 |
| Paints | 8,605 | 0 |
| Paper and Pulp | 104† | 0 |
| Pharmaceuticals | 682 | 682 |
| Others ‡ | 2,290 | 300 |
| Totals | 52,473 | 28,800 |

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*Based on total mercury loss of 0.02 lb/ton chlorine produced and a chlorine production capacity of 7,000 tons per day.

†Estimated

‡"Others" include mercury used for installation and expansion of chlor-alkali plants and amalgamation.

**SOURCES AND TYPES OF WASTE:** By far the single largest source of commercial discharges of mercury during 1968 was derived from inventory losses suffered by the chlor-alkali plants.

Of the mercury used in 1968 for other potentially recyclable uses, such as electrical equipment, measurement and control apparatus, and general laboratory uses, 520 tons were recycled and 660 tons had an unknown disposition, (in batteries, fluorescent tubes, switches, etc.) and probably ended up mostly in landfills, dumps, and incinerators.

The dissipative uses of mercury include paints, agriculture, dental fillings, catalysts, paper and pulp manufacture, and pharmaceuticals; a total of 26 percent (745 tons) of the mercury demand in 1968. Mercury from these various uses enter the environment in a variety of ways and at different rates.

Other man-made sources of environmental mercury include mine tailings and vapor released by the mining and smelting of mercury, and a stack loss of three percent during the refining process would mean that 31 tons were emitted into the atmosphere from smelting during 1968. In addition, ore deposits of heavy metals are generally surrounded by aureoles in which a notable enrichment in mercury has occurred, and considerable mercury generally escapes from stacks during the smelting of tin, zinc, copper, and gold. A single smelter handling 500 tons per day might emit as much as 10 lbs mercury vapor daily.

Another major source of airborne mercury is the combustion of paper products and fossil fuel. A conservative estimate of 550 tons of mercury is released annually in the United States by coal. It is believed that petroleum processing and oil burning contribute a substantial amount of mercury pollution in the U. S.

Mercury also enters into the environment through natural sources: Mercury ore deposits and precious metal or copper ore deposits, underground waters, oil field brines, hot springs, geothermal stream fields, and hot vapors which stream up through fine-grained muds produce mud volcanoes and deposit considerable quantities of mercury during condensation.

**TOXICOLOGY:** Inorganic mercury may enter into the body by absorption through inhalation of elemental mercury vapor or aerosols of mercuric salts and by oral ingestion. Penetration through the skin, on the other hand, is rather slow.

Inhalation of mercury in concentrations of 1,200 to 8,500 micrograms per cubic meter in air results in acute intoxication, affecting primarily the digestive system and kidneys, and is characterized by a metallic taste, nausea, abdominal pain, vomiting, diarrhea, headache, and sometimes albuminuria. After a few days, the salivary glands swell, stomatitis and gingivitis develop, and a dark line of mercuric sulfide forms on the inflamed gums. Furthermore, teeth may loosen and ulcers may appear on the lips and cheeks. Severe exposure to mercury vapor produces tightness and pain in the chest, difficulty in breathing, and coughing. Severe cases of acute poisoning are characterized in later stages by hemolysis, sleeplessness, headache, facial tics, digital tremors, delirium and hallucinations. Death as a result of cardiac exhaustion frequently occurs with poisoning of this degree of severity. In milder cases of acute mercury poisoning, some patients recover within 10 to 14 days, but others may develop the chronic symptoms, such as muscular tremors or erethism.

Chronic poisoning of mercury is more common than the acute form. In the case of chronic poisoning of inorganic mercury, symptoms and signs involving the central nervous system are most commonly seen, the principal features being tremors and phychological disturbances. Symptoms related to the mouth, such as gingivitis, stomatitis, and excessive salivation, may occur along with a number of nonspecific symptoms such as loss of appetite, weight loss, anemia, and muscular weakness. Intoxication from mercury vapor or from absorption of mercuric salts may be due, in both cases, to the action of the mercuric ion. Metallic mercury is able to diffuse much more extensively into the blood cells and various tissues than inorganic mercury, but once distributed, most of it is oxidized to the mercuric form. In most cases symptoms of mercury poisoning were observed only among workers who had been exposed to mercury levels above 100 micrograms per cubic meter in air.

It has been reported that a 1 gm oral dose of mercuric chloride could cause death in adults whereas a 0.1 gm dose would lead to chronic illness. The acute oral $LD_{50}$ of mercuric chloride to rat is 37 mg/kg body weight, and that mercuric nitrate to mouse is 4 mg/kg body weight.

The American Conference of Governmental Industrial Hygienists (ACGIH) has recommended as Threshold Limit Values (TLV) for 1971 a time-weighted average concentration of 50 micrograms per cubic meter in air for metallic mercury vapor and inorganic mercury compounds.

Mercuric chloride is toxic to aquatic life. No aquatic toxicity data are available for mercury, mercuric sulfate, or mercuric diammonium chloride, as mercuric sulfate decomposes in cold water into a yellow insoluble basic sulfate and free sulfuric acid, and both mercury and mercuric diammonium chloride are insoluble in cold water. It must be remembered, however, that mercury and all inorganic mercury compounds discharged into the aquatic environment could eventually be biologically converted into the more toxic methyl mercury by anaerobic microorganisms, which can then be concentrated through food chains to fish living in both fresh water and marine environments, thus leading to the present dimensions of the mercury pollution problem.

The Booz-Allen Ratings for these compounds are:

|  | HUMAN |  |  | ECOLOGICAL |  |  | EXPLOSION |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Mercury | 3 | 3 | 3 | 0 | 3 | 0 | 2 | 1 | 1 |

|  | HUMAN |  |  | ECOLOGICAL |  |  | EXPLOSION |  |  |
|---|---|---|---|---|---|---|---|---|---|
|  | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Mercuric Chloride | 3 | 3 | 3 | 3 | 3 | U | 2 | 1 | [illegible] |
| Mercuric Nitrate | 3 | 3 | 3 | U | 3 | U | [illegible] | 1 | 1 |
| Mercuric Sulfate | 3 | 3 | 3 | U | U | U | [illegible] | 1 | 1 |
| Mercuric Diammonium Chloride | 3 | 3 | 3 | U | U | U | 2 | 1 | 2 |

OTHER HAZARDS: All inorganic mercury compounds, with the notable exception of the halides, decompose to give toxic fumes of mercury on heating.

In addition to its toxic properties, mercuric nitrate also possesses some of the properties of nitrates. Acetylene forms a sensitive acetylide when passed into an aqueous solution of mercuric nitrate. Alcohols should not be mixed with mercuric nitrate, as explosive mercury fulminate may be formed. Reactions of mercuric nitrate and phosphine give a yellow precipitate, which explodes when heated or subjected to shock. Mercuric nitrate also reacts with unsaturates and aromatics with violence if given time to generate enough heat, and could lead to explosions in its use for determining sulfur in Ball's reaction.

HANDLING, STORAGE, TRANSPORTATION: Exercise care in handling to minimize contact with the skin or the inhalation of airborne dust, as well as ingestion. Safety precautions should include adequate ventilation of all work and storage areas, enforcing strict standards of housekeeping and personal cleanliness, and the use of protective equipment. Workers should be examined periodically by competent physicians, and referred to medical treatment after any mishap that might give rise to an abnormally high intake of mercury.

Store in tight containers. Mercury, mercuric chloride, and mercuric sulfate are classified as Poison B by the Department of Transportation (DOT). Although mercuric nitrate and mercuric diammonium chloride are not on the DOT list of hazardous materials, the same regulations for Class B poisons should also be applied in the transportation of these compounds.

Spilled mercury and inorganic mercury compounds on floors can normally be handled by several of the removal methods available. Sweeping with special vacuum cleaners, followed by flooding with water, collection of the water with suction pumps, and subsequent removal of the mercury from the contaminated water by chemical precipitation, chemical reduction, ion exchange, or solvent extraction methods. For the chemical removal of mercury, a substance is generally applied to react readily with mercury at ambient temperatures forming nearly nonvolatile mercury compounds, which can then be swept up.

Methods suggested for treating water spills of mercury and inorganic mercury compounds include adsorption with activated carbon and ion-exchanger masses.

DISPOSAL/REUSE: The greater portion of mercury and inorganic mercury compounds present in air and water waste streams can be removed and the mercury recovered for its value. The safe disposal of mercury and inorganic mercury compounds must be defined in terms of Recommended Provisional Limits in the atmosphere and potable water source and/or marine habitat. The Provisional Limits are as follows:

| Contaminant in Air | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Mercury | 0.0005 mg/M$^3$ | 0.01 TLV |
| Mercuric Chloride | 0.0005 mg/M$^3$ as Hg | 0.01 TLV |
| Mercuric Nitrate | 0.0005 mg/M$^3$ as Hg | 0.01 TLV |
| Mercuric Sulfate | 0.0005 mg/M$^3$ as Hg | 0.01 TLV |
| Mercuric Diammonium Chloride | 0.0005 mg/M$^3$ as Hg | 0.01 TLV |

| Contaminant in Water and Soil | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Mercury | 0.005 ppm (mg/l) | U.S. Drinking Water Standard |
| Mercuric Chloride | 0.005 ppm (mg/l) as Hg | U.S. Drinking Water Standard |
| Mercuric Nitrate | 0.005 ppm (mg/l) as Hg | U.S. Drinking Water Standard |
| Mercuric Sulfate | 0.005 ppm (mg/l) as Hg | U.S. Drinking Water Standard |
| Mercuric Diammonium Chloride | 0.005 ppm (mg/l) as Hg | U.S. Drinking Water Standard |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

REMOVAL FROM GASES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Mist eliminators with second stage unit to remove the last remaining traces. | Satisfactory |
| Union Carbide purasiv Hg system | Satisfactory |
| Absorption with activated carbon | Unsatisfactory, too expensive and inefficient. |
| Scrubbing with sodium hypochlorite solution. | Satisfactory |

REMOVAL FROM LIQUIDS:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Chemical precipitation | Unsatisfactory due to difficulty in removing precipitate |
| Chemical reduction with zinc | Satisfactory |
| Chemical reduction by the Ventron sodium borohydride process. | Satisfactory |
| Ion exchange by the OSAKA soda process | Satisfactory |
| Ion exchange by the Aktiebolaget Billingsfors Langed process | Satisfactory |

Some other iron exchange processes are satisfactory in some cases.

| | |
|---|---|
| Solvent extraction | Shows promise for the near future. |
| Chemical absorption | Laboratory and pilot plant data indicate satisfactory results. |
| Adsorption with activated carbon | Unsatisfactory does not reduce the mercury concentration below the recommended level. |

SOLID: No methods have been designed and placed into operation.

APPLICABILITY TO NATIONAL DISPOSAL SITES: Some types of mercury could best be treated at the site of generation. There are some however, where no simple method exists for adequate disposal or recovery, and these are prime candidate waste streams for National Disposal Sites.

# METHANE

CHEMICAL FORMULA: $CH_4$

GENERAL DESCRIPTION: Colorless, odorless, tasteless gas. Also called marsh gas and methyl hydride.
Molecular Wt.: 16.04 Melting Pt.: -184°C Boiling Pt.: -161.5°C
Density: (Liquid) 0.415 g/cc @ -164°C (Gas) 0.7168 g/l @ 0°C
Vapor Pressure:
Flash Pt.: Autoignition Temperature: 1000°F
Explosive Limits in Air (Wt%): Lower 5.3% Upper 14.0%
Solubility:
Hot Water: 9 cc @ 20°C/100ml Cold Water: Ethanol: 60 cc/100ml
Other: 91 cc @ 20°C in ether /100 ml
DOT Classification: Flammable gas, red label, 300 pounds
Coast Guard Classification: Flammable gas, red label
IATA Classification: Flammable gas, red label
Not acceptable (passenger), 140 kilograms (cargo)

TOXICOLOGY: Methane is a simple asphyxiant.

OTHER HAZARDS: Methane is a dangerous fire and explosion hazard when exposed to heat or flame.

HANDLING, STORAGE, TRANSPORTATION: Avoid breathing the fumes. Store in a well ventilated area away from heat and flames.

## METHYL CELLULOSE

CHEMICAL FORMULA

GENERAL DESCRIPTION: Grayish white fibrous powder. Also called cellulose methyl ether
Molecular Wt.: Varies from 40,000 to 180,000. Melting Pt.: ________
Boiling Pt.: ________
Density: (Solid) ____________________ (Gas) ____________________
Vapor Pressure: ____________________
Flash Pt.: ____________________ Autoignition Temperature: ________
Explosive Limits in Air (Wt%): Lower ____________ Upper ____________
Solubility:
Hot Water: ____________________ Cold Water: ____________________
Ethanol: Insoluble Other: Soluble in acetic acid, insoluble in ether and chloroform
DOT Classification: ____________________
Coast Guard Classification: ____________________

# NITRIC ACID

CHEMICAL FORMULA: $HNO_3$

GENERAL DESCRIPTION: Colorless to yellowish to red, fuming, corrosive and poisonous liquid. Also called aqua fortis, hydrogen nitrate and azotic acid.
Molecular Wt.: 63.01 Melting Pt.: -42°C Boiling Pt.: 83°C
Density: (Liquid) 1.502 g/cm (Gas) ____
Vapor Pressure: ____
Flash Pt.: ____ Autoignition Temperature: ____
Explosive Limits in Air (Wt%): Lower ____ Upper ____
Solubility:
Hot Water: Infinitely Cold Water: Infinitely Ethanol: ____
Other: ____
DOT Classification: Corrosive liquid, white label
Coast Guard Classification: Corrosive liquid, white label

MANUFACTURE: By the ammonia oxidation process.

USES: About 70 to 80% of $HNO_3$ is used to produce ammonium nitrate which is used as a fertilizer, approximately 5-10% is used to produce cyclohexanone which is raw material for making the monomers for nylon, the rest is used for making various nitrates and nitro compounds.

TOXICITY: Nitric acid is very corrosive. Its vapor is highly irritating to the skin and the mucous membranes of the eyes and respiratory tract. Continued exposure to the vapor may cause chronic bronchitis and chemical pneumonia. Ingestion of nitric acid causes burning and corrosion of mouth, esophagus and stomach, abdominal tenderness, shock and death.

The Threshold Limit Value (TLV) for nitric acid is 5 mg/m³.

The Booz-Allen Ratings for nitric acid are:

| | HUMAN | | | ECOLOGICAL | | | AESTHETIC | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 1 | 1 | 2 | 1 | 2 | 1 |

OTHER HAZARDS: Nitric acid is a powerful oxidizing agent, and a moderate fire hazard by chemical reaction with reducing agents. It can also explode on contact with powerful reducing agents.

HANDLING, STORAGE, TRANSPORTATION: Corrosive materials such as nitric acid must be handled carefully. Contact with skin and inhalation of the fumes should be avoided. It should be kept away from heat. Since nitric acid is a powerful oxidizer it should not be stored near reducing agents or combustible materials. Containers should be kept tightly closed when not in use.

DISPOSAL/REUSE: For the safe disposal of nitric acid into the environment, the following Provisional Limits should be considered:

| Nitric Acid as a Contaminant in... | Maximum Exposure Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.05 mg/M$^3$ | 0.01 TLV |
| | Provisional Limit | |
| Water and Soil | 0.25 ppm (mg/l) | Stokinger and Woodward Method. |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Neutralization with soda ash-slaked lime solution. The neutral solution of sodium and calcium nitrate formed can be discharged after water dilution. | Satisfactory |
| Regeneration by steam distillation | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Nitric acid as a waste stream constituent can be adequately handled at industrial sites and is not considered a candidate for National Disposal Sites.

# NITROBENZENE

CHEMICAL FORMULA: $C_6H_5NO_2$,

GENERAL DESCRIPTION: Bright yellow crystals or pale yellow liquid with an almond like odor. Also called nitrobenzol, oil of mirbane.
Molecular Wt.: 123.11 Melting Pt.: 5.7°C Boiling Pt.: 210.9°C
Density: (Liquid) 1.1987 g/cc @ 25°C (Gas) 4.25 g/l
Vapor Pressure: 1 mm @ 44.4°C; 22 mm @ 100°C; 50 mm @ 120°C
Flash Pt.: 87.8°C (C.C.) Autoignition Temperature: 900°F
Explosive Limits in Air (Wt%): Lower 1.8% @ 200°F Upper
Solubility:
Hot Water: 0.8 g/100cc@80°C Cold Water: Very slightly Ethanol: Very
Other: Very soluble in ether, benzene and oils
DOT Classification: Poison B, poison label, 55 gal max container
Coast Guard Classification: Poison B, poison label.

MANUFACTURE: Direct nitration of benzene using mixed sulfuric and nitric acid. Large scale commercial manufacturers are Allied, Cyanamid, First Chemical, Mobay, Monsanto and Rubicon.

USES: Manufacture of aniline for the synthesis of dyestuffs, rubber chemicals, photographic chemicals and drugs.

TOXICOLOGY: Highly toxic. Readily absorbed through the skin, by inhalation or by ingestion. Nitrobenzene may be almost immediately fatal if large areas of the body are in contact with the liquid or if harmful concentrations are inhaled.

The Threshold Limit Value and Maximum Allowable Concentrations are 0.01 mg/l and 1 ppm (5 mg/M$^3$) respectively and acute aquatic toxicity occurs at about 10 mg/l. The lethal dose orally in rabbits is 700 mg/kg.

The Booz-Allen Ratings for Nitrobenzene are:

| HUMAN | | | BIOLOGICAL | | | AESTHETIC | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 2 | 3 | 3 | 1 | 1 | 2 |

OTHER HAZARDS: Moderate fire and explosive hazard when exposed to heat or flames.

HANDLING, STORAGE, TRANSPORTATION: Wear protective clothing and respirators when handling. Handle and store in a cool, well ventilated place away from heat or open flames. Ship according to DOT regulations.

DISPOSAL/REUSE: Aqueous waste streams of nitrobenzene are given primary and secondary treatment with lime and activated sludge digestion before being discharged into waterways.

For disposal of nitrobenzene into the environment the following Provisional Limits are recommended:

| Nitrobenzene in | Provisional Limits | Basis for Recommendation |
|---|---|---|
| Air | 0.01 ppm (0.05 mg/M$^3$) | 0.01 TLV |
| Water and Soil | 0.25 ppm (0.05 mg/l) | Stokinger & Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| CONCENTRATED NITROBENZENE | |
| Return to manufacturer when contaminated | Best method |
| Incineration under controlled methods. | Satisfactory |
| Open Burning | Not acceptable, oxides of nitrogen and incomplete combustion products may be generated. |
| Landfill | Only if landfills meet California class 1 requirement. |
| Dilution of small amounts followed by secondary treatment. | Satisfactory |
| DILUTE AQUEOUS WASTE | |
| Primary treatment followed by lime to adjust the pH to 7. Mix with municipal sewage, let equilibrate one day then lagoon for 20 hours with municipal aeration | Satisfactory |
| Secondary treatment with activated sludge | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Nitrobenzene waste can be handled adequately at the source of generation provided it can be recycled or incinerated in a safe manner. It is not considered to be a candidate for National Disposal Sites.

# para-NITROPHENOL

CHEMICAL FORMULA: $NO_2C_6H_4OH$

GENERAL DESCRIPTION: Colorless to slightly yellow crystalline solid. Also called 4-nitrophenol.
Molecular Wt.: 139.1 Melting Pt.: 113-114° Boiling Pt.: 279°C d.
Density: (Solid) 1.270 g/cc @ 120°C (Gas) ______
Vapor Pressure: ______
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt.%) Lower ______ Upper ______
Solubility:
Hot Water: 29 gm/100ml@90°C Cold Water: 1.6 gm/100 ml @ 25°C
Ethanol: Very soluble Other: Very soluble in chloroform & ether
DOT Classification: ______
Coast Guard Classification: ______

MANUFACTURE: By the hydrolysis of the corresponding nitrochlorobenzene with 15 percent sodium hydroxide at 160°C.

USES: The nitrophenols are used as intermediates in the preparation of dyestuffs, plant sprays (parathion), aminophenols and photochemicals.

TOXICOLOGY: Nitrophenols are very toxic when ingested, inhaled or absorbed through the skin. The characteristic effects of poisoning are an increased metabolism with a rise in body temperature, headache, heavy sweating, thirst, fatigue and just before death a sudden rise in body temperature. Chronic exposure is often characterized by hyperthermia, methemoglobinemia, depression, liver and kidney damage, cataracts, eczema, inflammation of the lymphatic glands and degeneration of the cells. Paranitrophenol is the most toxic of the three mononitrophenols.

The Maximum Allowable Concentration (MAC) for nitrophenol is 4 mg/M³. The Booz-Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 1 | 3 | 1 | 2 | 1 | 0 | 3 | 1 | 2 |

OTHER HAZARDS: No other hazards than those mentioned under toxicology.

HANDLING, STORAGE AND TRANSPORTATION: Handle in a well-ventilated area. Avoid all skin contact. Wear protective clothing and respirators when necessary. In case of accidental contact, remove all contaminated clothing and wash the skin with soap and water. Bicarbonate solutions will help in the removal of the nitrophenols.

Store in a cool, dry, well-ventilated area, away from acute fire hazards.

DISPOSAL/REUSE: A dilute aqueous waste stream and a small amount of distillation bottoms are produced in the manufacture of nitrophenols. The Manufacturing Chemists Association suggests that small quantities be disposed of by open burning or as a slurry by washing down the sewer. Disposal of large quantities by landfill in areas reserved for toxic wastes is suggested.

Recommended Provisional Limits for release of nitrophenol waste into the environment are as follows:

| Nitrophenol in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.002 mg/M$^3$ | Based on similar compounds |
| Water and Soil | 0.010 ppm (mg/l) | Based on similar compounds |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Treatment of waste water to reduce biological and chemical oxygen demand. | Satisfactory |
| Controlled incineration with the use of scrubbers and/or thermal or catalytic devices to control the effluent oxides of nitrogen. | Satisfactory |
| Flushing small quantities down the sewer as a slurry. | Not satisfactory due to hazard caused by accumulation of vapors and damage to activated sludges in treatment plants due to insufficient dilution. |
| Landfill of large quantities at special toxic wastes landfill sites of the California Class 1 type. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Waste nitrophenols can best be treated by industrial and municipal treatment, by incineration or by landfill at special sites. Nitrophenol as a waste stream constituent is not considered a candidate for National Disposal Sites.

## PHOSPHORUS CHLORIDES
## (PHOSPHORUS OXYCHLORIDE, PHOSPHORUS PENTACHLORIDE, PHOSPHORUS TRICHLORIDE)

### PHOSPHORUS OXYCHLORIDE

CHEMICAL FORMULA: $POCl_3$

GENERAL DESCRIPTION: Clear colorless fuming liquid. Also called phosphoryl chloride.

Molecular Wt.: 153.35 Melting Pt.: 1.25°C Boiling Pt.: 107.2°C
Density: (Liquid) 1.675 g/cc @ 20°C (Gas) 5.30 g/l
Vapor Pressure: 10 mm @ 2.73°C; 100 mm @ 47.1°C; 400 mm @ 84.3°C
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Vol%): Lower ________ Upper ________
Solubility:
Hot Water: Decomposes Cold Water: Decomposes Ethanol: Decomposes
Other: Carbon tetrachloride
DOT Classification: Corrosive liquid, white label, 1 quart
Coast Guard Classification: Corrosive liquid
MCA Warning Label
IATA Classification: Corrosive liquid, white label,
Not acceptable (passenger), 1 litre (cargo)

MANUFACTURE: Phosphorus trichloride oxidized with pure oxygen and air

### PHOSPHORUS PENTACHLORIDE

CHEMICAL FORMULA: $PCl_5$

GENERAL DESCRIPTION: A yellow white crystalline solid.

Molecular Wt.: 208.3 Melting Pt.: 148°C Under Pressure Boiling Pt.: Sublimes at 160 °C
Density: (Solid) 1.6 g/cc @ 20°C (Gas) 4.65 g/l @ 296°C
Vapor Pressure: 1 mm Hg @ 55.5°C; 10 mm Hg @ 83.2°C; 100 mm Hg @ 117°C
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Vol%): Lower ________ Upper ________
Solubility:
Hot Water: -- Cold Water: Decomposes
Ethanol: ________ Other: Carbon tetrachloride, carbon disulfide, benzoyl chloride
DOT Classification: Flammable solid
Coast Guard Classification: Flammable Solid

MANUFACTURE: Phosphorus trichloride reacted with gaseous chlorine.

# PHOSPHORUS TRICHLORIDE

CHEMICAL FORMULA: $PCl_3$

GENERAL DESCRIPTION: A colorless fuming liquid with pungent, irritating odor resembling that of hydrochloric acid. Also called phosphorus chloride.
Molecular Wt.: 137.35 Melting Pt.: -111.8°C Boiling Pt.: 75.5°C
Density: (Liquid) 1.575 g/cc @ 20°C (Gas) 4.75 g/l @ 20°C
Vapor Pressure: 400 mm Hg @ 56.9°C; 100 mm Hg @ 21°C
Flash Pt.: Nonflammable Autoignition Temperature: None
Explosive Limits in Air (wt%): Lower __________ Upper __________
Solubility:
Hot Water: Decomposes Cold Water: Decomposes Ethanol: Soluble
Other: Chloroform, ether, benzene, carbon disulfide, carbon tetrachloride
DOT Classification: Corrosive Liquid
Coast Guard Classification: Corrosive Liquid

MANUFACTURE: Direct union of red or white phosphorus and gaseous chlorine. Most phosphorus chlorides are manufactured by: Monsanto, Sauget, Illinois/ FMC, Nitro, West Virginia; Hooker, Niagara Falls, New York and Stauffer, Morrisville, Pennsylvania.

USES: All three, $POCl_3$, $PCl_5$, and $PCl_3$, are used in manufacture of organic-phosphorus compounds.

$POCl_3$: Organic synthesis of phosphate esters (tricresyl phosphate, a common plasticizer), in production of gasoline additives, insecticides, fire resistant hydraulic fluids and flame retardants.

$PCl_5$: A chlorinating agent and catalyst in organic synthesis, catalyst in lubricant additive production and insecticide manufacture.

$PCl_3$: Manufacture of organic acid chlorides, dye stuffs, organic antioxidants, vinyl stabilizers and plasticizers.

SOURCE AND TYPES OF WASTE: Main source is the material remaining in containers after emptying. Essentially no production waste. No dilute waste, all decomposes upon contact with water. Decomposition products are hydrochloric and phosphoric acid.

TOXICOLOGY: Phosphorus trichloride and phosphorus pentachloride: Prompt irritation of the eyes, nose, throat and lungs (all mucous membranes) from small amount in air, suffocation, bronchitis, edema and lung inflammation from extended exposures. Severe exposure (600 ppm) is lethal in a few minutes. Vapors irritating to skin. Liquid and solid can cause immediate severe skin burns. TLV for $PCl_3$ in air is 0.5 ppm or 3 mg/M$^3$; and for $PCl_5$ in air is 1 mg/M$^3$.

Phosphorus oxychloride: Vapors irritating to all mucous membranes and to lungs. Liquid causes severe skin burns. Inhalation symptoms range from coughing to delayed wheezing due to bronchial irritation or pulmonary edema.

Aquatic toxicity: None, all decompose to HCl and $H_3PO_4$ in water. 0.1-10 ppm $H_3PO_4$ affect fish. 1.0 ppm HCl will affect fish.

The Booz-Allen Ratings for these phosphorous chloride compounds are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| Phosphorus Oxychloride | 3 | 3 | 3 | 0 | 0 | 0 | 2 | 2 | 2 |
| Phosphorus Pentachloride | 3 | 3 | 3 | 3 | 0 | 0 | 2 | 2 | 2 |
| Phosphorus Trichloride | 3 | 3 | 3 | 0 | 3 | 0 | 2 | 2 | 2 |

OTHER HAZARDS: $PCl_3$ and $PCl_5$ neither flammable nor explosive. Each reacts violently with small amounts of water liberating heat, spontaneously flammable phosphine gas, HCl, $H_3PO_4$ and spontaneously flammable phosphorus $POCl_3$ neither flammable nor explosive. Corrosive in pure state. Reacts violently with water, giving off HCl, $H_3PO_4$ and steam. Reacts violently with alkalies and fibrous organic matter.

HANDLING, STORAGE, TRANSPORTATION: Protective clothing should be worn including gas-tight safety goggles, face shields, rubber shoes, rubber gloves, rubber apron and acid-gas canister type respirator. Use fume scrubbers when loading drums, tank cars or tank trucks. Store in a well ventilated, cool, dry area. Use ceramic-lined, lead-lined or nickel-lined drums and keep sealed when storing the two liquids. Solid $PCl_5$ can be stored in ordinary steel carboys or steel drums. Keep containers tightly closed.

DISPOSAL/REUSE: Recycle to plant production, decomposition with large amounts of water. For large amounts, add phosphoric acid or add the phosphorous chloride to large amounts of water, neutralize and sewer.

Provisional Limits for Disposal:

| In Air | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Phosphorus Oxychloride | 0.07 mg/M$^3$ as HCl | 0.01 TLV for HCl |
| Phosphorus Trichloride | 0.03 mg/M$^3$ | 0.01 TLV |
| Phosphorus Pentachloride | 0.01 mg/M$^3$ | 0.01 TLV |

| In Water & Soil | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Phosphorus Oxychloride | 0.35 ppm (mg/l) | Stokinger and Woodward Method |
| Phosphorus Trichloride | 0.15 ppm (mg/l) | Stokinger and Woodward Method |
| Phosphorus Pentachloride | 0.05 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Removal from air by refrigerated condensation and by water decomposition | Satisfactory |
| In water, they are not removed, only neutralized and sent to sewer. Concentrated waste is recycled, decomposed with water or chemically degraded with $H_3PO_4$. The decomposed and degraded products are neutralized and sewered. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: These materials are not considered candidates for National Disposal Site disposal.

# POLYVINYL ALCOHOL

CHEMICAL FORMULA:

$-CH_2\underset{OH}{CH}(CH_2\underset{OH}{CH})_2CH_2\underset{OH}{CH}-$

GENERAL DESCRIPTION: Colorless, amorphous powder.

Molecular Wt.: ________ Melting Pt.: decomposes over 200°C Boiling Pt.:

Density: (Solid) 1.329 g/cc ________ (Gas) ________

Vapor Pressure: ________

Flash Pt.: 175° F (O.C.) ________ Autoignition Temperature: ________

Explosive Limits in Air (Wt%): Lower ________ Upper ________

Solubility:

Hot Water: ________ Cold Water: ________

Ethanol: ________ Other: ________

DOT Classification: ________

Coast Guard Classification: ________

TOXICOLOGY: Not considered toxic. Details not known.

OTHER HAZARDS: Slight fire hazard when exposed to heat or flame, or by reaction with oxidizing materials. Poly vinyl alcohol is a slight explosion hazard when exposed to flame in the form of dust.

HANDLING, STORAGE, TRANSPORTATION: Store in a cool place away from heat flame and oxidizing materials.

# PROPANOL

## 1 - PROPANOL

CHEMICAL FORMULA: $CH_3CH_2CH_2OH$

GENERAL DESCRIPTION: Clear, odorless liquid with an alcohol like odor. Also called n-propyl alcohol and ethyl carbinol.
Molecular Wt.: 60.09 Melting Pt.: -127°C Boiling Pt.: 97.19°C
Density: (Liquid) 0.8044 g/cc @ 20°C (Gas) 2.07 g/l
Vapor Pressure: 10 mm @ 14.7°C
Flash Pt.: 59°F (C.C.) Autoignition Temperature: 700°F
Explosive Limits in Air (Wt%): Lower 2.1% Upper 13.5
Solubility:
Hot Water: Infinitely sol. Cold Water: ______ Ethanol: Inf. sol.
Other: Infinitely soluble in ether
DOT Classification: ______
Coast Guard Classification: ______

## 2 - PROPANOL

CHEMICAL FORMULA:

$CH_3-\overset{CH_3}{CH}-OH$

GENERAL DESCRIPTION: Clear colorless liquid. Also called dimethylcarbinol, sec-propyl alcohol, isopropanol and iso-propyl alcohol
Molecular Wt.: 60.09 Melting Pt.: -88.5 -89.5°C Boiling Pt.: 82.3°C
Density: (Liquid) 0.7854 g/cc @ 20°C (Gas) 2.07 g/l
Vapor Pressure: 33.0 mm @ 20° C
Flash Pt.: 53°F Autoignition Temperature: 750°F
Explosive Limits in Air (Wt%): Lower 2.0% Upper 12%
Solubility:
Hot Water: Inf. soluble Cold Water: Inf. sol. Ethanol: Inf. sol.
Other: Infinitely soluble in ether
DOT Classification: Flammable liquid
Coast Guard Classification: ______
MCA Warning label

TOXICOLOGY: Isopropyl alcohol is a local irritant. It produces a narcotic effect in high concentration.

It produces a mild irritation to the eyes, nose and throat at concentration levels of 400 ppm.

The tentative Threshold Limit Value for n-propyl alcohol is 200 ppm (510 mg/M$^3$) in air.

The Booz-Allen Ratings are:

| | HUMAN | | | BIOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|---|
| | Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 1-Propanol | 1 | 1 | 1 | 1 | 2 | 0 | 2 | 1 | 1 |
| 2-Propanol | 2 | 2 | 1 | 1 | 2 | 0 | 2 | 1 | 2 |

OTHER HAZARDS: Propyl alcohol is a fire and explosion hazard when exposed to heat and flame. It can react vigorously with oxidizing materials.

HANDLING, STORAGE, TRANSPORTATION: Avoid eye and skin contact and breathing of vapors. Store in a cool well ventilated area away from heat, flame and oxidizing materials.

# PROPARGYL ALCOHOL

CHEMICAL FORMULA: $CH \equiv CCH_2OH$

GENERAL DESCRIPTION: A moderately volatile liquid with a geranium-like odor. IUC Name: 2-propyn-1-ol. Also called ethynylcarbinol, acetylenyl carbinol and propiolic alcohol.

Molecular Wt.: 56.06 Melting Pt.: -17°C Boiling Pt.: 114°C
Density: (Liquid) 0.9715 g/cc @ 20°C (Gas) 1.93 g/l
Vapor Pressure: 11.6 mm @ 20°C
Flash Pt.: 97° F (O.C.) Autoignition Temperature: ____
Explosive Limits in Air (wt%): Lower ____ Upper ____
Solubility:
Hot Water: Soluble Cold Water: Soluble Ethanol: Infinitely
Other: Infinitely soluble in ether
DOT Classification: ____
Coast Guard Classification: ____

TOXICOLOGY: Very toxic by ingestion, inhalation and absorption through the skin.

OTHER HAZARDS: Moderate fire hazard when exposed to heat or flames. It can react with oxidizing materials.

HANDLING, STORAGE, TRANSPORTATION: Wear protective equipment when handling. In case of contact wash with soap and water. Remove all contaminated clothing and wash before reuse.

Store in a cool well ventilated place away from heat or flame.

## RADIUM-226

CHEMICAL FORMULA: $_{88}Ra^{226}$

GENERAL DESCRIPTION: Radium is a silver-white radioactive metal. It is one of the most hazardous radionuclides.
Atomic Wt.: 226 Melting Pt.: 700°C Boiling Pt.: 1737° C
Density (Solid): 5 g/cc
Half-life: 1602 years
Type of Decay: Alpha
Specific Power: $1.3 \times 10^{-4}$ watts/gm Specific Activity: 0.99 curies/gm
Solubility:
Cold Water: Reacts and evolves $H_2$ Hot Water: Reacts and evolves $H_2$
Others: Reacts with acid
DOT Classification: Transport group 1 radionuclide

DECAY CHAIN:

| Nuclide | Name | Half-Life | Major Radiation |
|---|---|---|---|
| $_{88}Ra^{226}$ | Radium-226 | 1602 years | Alpha and gamma |
| $_{86}Rn^{222}$ | Radon-222 | 3.8 days | Alpha and gamma |
| $_{84}Po^{218}$ | Polonium-218 | 3.0 minutes | Alpha |
| $_{82}Pb^{214}$ | Lead-214 | 26.8 minutes | Beta and gamma |
| $_{83}Bi^{214}$ | Bismuth-214 | 19.7 minutes | Alpha, beta, and gamma |
| $_{84}Po^{214}$ | Polonium-214 | 64 micro seconds | Alpha |
| $_{82}Pb^{210}$ | Lead-210 | 21 years | Beta and gamma |
| $_{83}Bi^{210}$ | Bismuth-210 | 5 days | Beta |
| $_{84}Po^{210}$ | Polonium-210 | 138 days | Alpha |
| $_{82}Pb^{206}$ | Lead-206 | Stable | |

MANUFACTURE: Radium-226 is a daughter of uranium-238 and occurs naturally in the earths surface.

USES: Radium-226 is used in timepieces, electron tubes, static eliminator brushes, gauges, fire detectors, and in various self-luminous products. It is used in medicine for the treatment of tumors, superficial skin lesions, lymphoid tissue and other diseases. It is used at 2,300 facilities.

TOXICOLOGY: The ingestion of the luminous dial paint prepared from radium caused the death of many early dial painters.

RADIATION HAZARD: Radium-226 is one of the most hazardous radioactive materials known. It replaces calcium in the bone structure and is a source of irradiation to the blood forming organs. This along with its long half-life and high radiation energies puts it in the highest radiotoxicity group.

The effects of radiation exposure is primarily dependent on the amount of radiation and the portion of the body affected. The effects of whole-body gamma radiation exposure are: (1) 5 to 25 rads, minimal dose detectable by chromosome analysis or other specialized analysis, but not by hemogram; (2) 50 to 75 rads, minimal acute dose readily detectable in a specific individual (e.g., one who presents himself as a possible exposure case); (3) 75 to 125 rads, minimal acute dose likely to produce vomiting in about 10 percent of people so exposed; (4) 150 to 200 rads, acute dose likely to produce transient disability and clear hematological changes in a majority of people so exposed; (5) 300 rads, median lethal dose for single short exposure. These effects are for a single large dose of radiation or a series of substantial doses in a short interval of time to the total body. The dose delivered to the bone following the inhalation of 1 microcurie of radium-226 is 300 rem. The dose delivered to the bone following the injection of 1 microcurie into the body via a wound is 1,000 rem.

Standards for prolonged exposure over a 50-year period have defined the single dose limit in terms of the maximum permissible dose accumulated in a period of 13 weeks. The whole body exposure limit is 3 rem per quarter for a radiation worker and the accumulated dose limit is 5(N - 18), where N is the individual's age in years. Limits for the thyroid, bone, and other organs have also been defined. Values of the total body burden for each radionuclide required to produce the maximum permissible dose rates defined above have been compiled. For radium-226 the critical organ is the bone and the maximum permissible body burden is 0.1 microcuries.

OTHER HAZARDS: The fire and explosive hazard is moderate.

HANDLING, STORAGE, TRANSPORTATION: Radium 226 is hazardous to man by inhalation, ingestion or direct radiation exposure. Great care should be exercised in handling it. Excessive exposure to personnel should be avoided.

Special procedures and adequate radiation shielding are required in handling it. To detect and control personnel exposure to radiation, everyone working with radium 226 should wear dosimetry devices which directly indicate the dose. Other devices used for this purpose are the film badge and the thermoluminescent dosimeters.

Specially constructed containers in controlled areas should be used for storing large quantities. They should be protected by both a primary and a secondary containment barrier. Special monitoring systems and proper warning signs should be located in the storage area. Stored radium-226 should be vented to prevent the build-up of radon gas.

DISPOSAL/REUSE: For the safe release of radium-226 to the environment, the following Permissible Concentrations should not be exceeded:

MAXIMUM PERMISSABLE CONCENTRATIONS

| FORM | Concentrations in Air (microcuries/milliliter) | Concentration in Water (microcuries/milliliter) |
|---|---|---|
| Soluble | $3 \times 10^{-12}$ | $3 \times 10^{-8}$ |
| Insoluble | $2 \times 10^{-12}$ | $3 \times 10^{-5}$ |

The release may be limited even further, if a suitable sample of the population is exposed to one-third concentrations in air or water as specified above.

The release in a sanitary sewage system is limited to 0.1 microcuries of radium-226. Radium is exempt from AEC control and regulation and control is a state function. Some states require licensing for possession and use and in others no license is required. Therefore, the disposal, transportation and use of radium in some uses is not subject to the above regulations.

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Land burial | Not Satisfactory. It has an extremely long half-life and a high radiotoxicity |
| Near-surface solid storage | Satisfactory |
| Salt Deposits | satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Radium-226 is a candidate for a National Disposal Site due to its large commercial use and high health hazard.

# SILICA

CHEMICAL FORMULA: $SiO_2$

GENERAL DESCRIPTION: Colorless crystalline solid. Also called silicon dioxide, silicic anhydride, cristobalite, quartz, lechatelierite, tridymite. It also exists in amorphous form as opal, silica gel and fused silica

Molecular Wt.: 60.08 Melting Pt.: 1610°C Boiling Pt.: 2230°C

Density: (Solid) 2.19-2.66 g/cc Vapor ______

Vapor Pressure: ______

Flash Pt.: ______ Autoignition Temperature: ______

Explosive Limits in Air (Wt%): Lower ______ Upper ______

Solubility:

Hot Water: Insoluble Cold Water: Insoluble

Ethanol: Insoluble Other: Soluble in HF

DOT Classification: ______

Coast Guard Classification: ______

MANUFACTURE: Occurs plentifully in nature as sand, quartz, flint, chalcedony, opal, agate and infusorial earth.

USES: In the manufacture of glass, ceramics, enamels, refractories, abrasives, concrete, bricks, building stones, water glass, and soluble silicates, silicon and its alloys, silicon carbide, silicon-based chemicals and the silicones. As a desiccant, an adsorbent or a catalyst.

TOXICITY: Prolonged inhalation may result in a diffuse fibrosis known as silicosis. This fibrosis may continue to develop for several years after exposure is terminated. This condition is indicated by shortness of breath, and a limitation of chest expansion. There may be a dry cough with increasing susceptibility to tuberculosis. Further progress of the disease results in more severe shortness of breath and cough, marked fatigue, extreme dyspnea and cyanosis, loss of appetite, pleuritic pain and total incapacity to work. If tuberculosis does not supervene, the conditions may eventually cause death from either cardiac failure or destruction of lung tissue with resultant anoxemia.

The Threshold Limit Values and Lethal Dose are:

| TLV | Lethal Dose |
|---|---|
| - | or $LD_{50}$:3160 mg/kg, rat |

The Booz-Allen Ratings are:

| | HUMAN | | | BIOLOGICAL | | | AESTHETIC | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 1 | 1 | 1 | 0 | 0 | 0 | 1 | 1 | 1 |

OTHER HAZARDS: None

HANDLING, STORAGE, TRANSPORTATION: In handling silica, avoid breathing silica dust.

DISPOSAL: The Provisional Limits and safe disposal of silica into the environment are:

| Silica as a Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.1 mg/M$^3$ | 0.01 TLV for Si |
| Water and Soil | " | " |

EVALUATION OF WASTE MANAGEMENT:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Landfill | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES:

Silica is not a candidate for National Disposal Sites

# SILICON TETRACHLORIDE

CHEMICAL FORMULA: $SiCl_4$

GENERAL DESCRIPTION: Colorless, fuming liquid with a suffocating odor. Also called silicon chloride.

Molecular Wt.: 169.90 Melting Pt.: -70°C Boiling Pt.: 57.57°C
Density: (Liquid) 1.483 g/cc @ 20°C (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Decomposes Cold Water: Decomposes Ethanol: Decomposes
Other:
DOT Classification: Corrosive liquid, white label
Coast Guard Classification: Corrosive liquid, white label
IATA Classification: Corrosive liquid, white label
1 liter (passenger) 5 liters (cargo)

MANUFACTURE: By reacting silicon carbide with chlorine gas.

USES: In producing smoke screens (fumed silica) in warfare, in the manufacture of high purity silicon, in the synthesis of silicon esters and in making special glass for the electronic industry.

TOXICOLOGY: Basically non-toxic, but is irritating to the eyes and respiratory tract. The lethal concentration for silicon tetra chloride is ih $LC_{Lo}$: 8000 ppm, rat.

The Booz-Allen Ratings are:

| | HUMAN | | | BIOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 3 | 0 | 0 | 2 | 2 | 2 |

OTHER HAZARDS: Silicon tetrachloride emits toxic fumes of hydrochloric acid when heated to decomposition. It will also react with water or steam to produce toxic and corrosive fumes.

HANDLING, STORAGE, TRANSPORTATION: Silicon tetrachloride should be handled carefully. Contact with skin and inhalation of the fumes should be avoided. It should be kept away from heat. The container should be kept tightly closed.

DISPOSAL/REUSE: For the safe disposal of silicon tetrachloride the following Provisional Limits are recommended.

| $SiCl_4$ as a Contaminant in | Maximum Exposure Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.1 mg/M3 as Si | 0.01 TLV for Si |
|  | Provisional Limit |  |
| Water and Soil | 0.50 ppm | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Neutralization with soda ash-slaked lime solution. The neutral solution of sodium or calcium chloride is discharged after dilution. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Waste streams containing silicon tetrachloride can be adequately treated at the site of generation and are not considered candidates for National Disposal Sites.

# SILVER CHLORIDE

CHEMICAL FORMULA: $AgCl$

GENERAL DESCRIPTION: White crystalline powder.
Molecular Wt.: 143.34 Melting Pt.: 455°C Boiling Pt.: 1550°C
Density: (Solid) 5.561 g/cc (Gas) ________
Vapor Pressure: 1 mm @ 912°C
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Wt%): Lower ________ Upper ________
Solubility:
Hot Water: 0.0021g/100 ml@100°C Cold Water: Insoluble
Ethanol: ________ Other: Soluble in $NH_4OH$, $Na_2S_2O_3$, KCN
DOT Classification: ________
Coast Guard Classification: ________

TOXICOLOGY: Silver compounds absorbed into the circulation and then deposited in various body tissues may produce a generalized greyish pigmentation of the skin and mucous membranes, a condition known as argyria. The introduction of fine particles of silver through breaks of the skin produces a local pigmentation at the site of the injury. Once deposited there is no known method by which the silver can be eliminated. The pigmentation is permanent. There are no constitutional symptoms and no physical disability. The Threshold Limit Value for silver is 0.01 mg/M$^3$.

OTHER HAZARDS. Chlorides, when heated to decomposition or on contact with acid or acid fumes, evolve highly toxic chloride fumes.

## SODIUM FERROCYANIDE

CHEMICAL FORMULA: $Na_4Fe(CN)_6 \cdot H_2O$

GENERAL DESCRIPTION: Pale yellow crystalline solid. Also called yellow prussiate of soda.

Molecular Wt.: 484.11 Melting Pt.: ____ Boiling Pt.: ____

Density: (Solid) 1.458 g/cc ____ (Gas) ____

Vapor Pressure: ____

Flash Pt.: ____ Autoignition Temperature: ____

Explosive Limits in Air (Wt%): Lower ____ Upper ____

Solubility:

Hot Water: 156.5 g/100 ml @ 98°C Cold Water: 31.58 g/100 ml @ 31.85°C

Ethanol: Insoluble ____ Other: ____

DOT Classification: ____

Coast Guard Classification: ____

USE: As a food and drinking water additive for animals and for the treatment of food producing animals. Permitted in food for human consumption.

## SODIUM FLUORIDE

**CHEMICAL FORMULA:** NaF

**GENERAL DESCRIPTION:** Colorless crystalline solid. Also called villiaumite.
Molecular Wt.: 42.00 Melting Pt.: 993°C Boiling Pt.: 1704°C
Density: (Solid) 2.78 g/cc (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: 5 g/100 ml @ 100°C Cold Water: 4 g/100 ml @ 0°C
Ethanol: Very slightly soluble Other:
DOT Classification:
Coast Guard Classification:
MCA Warning Label:

**MANUFACTURE:** By reacting soda ash with 40 percent hydrofluoric acid.

**USES:** As an insecticide, in other pesticide formulations, in the fluoridation of water, in soldering and metallurgical fluxes, in the manufacture of rimmed steel, in electroplating, as a constituent of vitreous enamel and opal glass mixes, in heat treating salts, for pickling stainless steel, as a disinfectant in breweries and distilleries, as a glue and paste adhesive, preservative, in the manufacture of coated papers.

Sodium fluoride solution is applied topically to the teeth as a 2 percent solution for prevention of dental cavities.

**TOXICOLOGY:** All alkali and ammonium fluorides can cause both acute and chronic poisoning. It causes extreme nausea and vomiting, perspiration, salivation, burning, cramp-like abdominal pains, diarrhea, dehydration and thirst, muscle weakness, hemorrhagic gastroenteritis, central nervous depression, cyanosis, shock, weak and thready pulse, shallow unlabored respiration, weak heart tones, paralysis of the muscles of deglutition, carpopedal spasm, spasm of the extremities and in extreme cases, death. Chronic contact can cause a crippling disease known as crippling fluorosis.

In animals fluoride poisoning can cause loss of appetite and starvation and in general the same effects as in man. Chronic effects are dental lesions, hypertosis, lameness, loss of appetite, decreased milk production and diminution in reproduction.

In plants fluoride poisoning causes necrosis, where injured portions of the leaves die and become discolored, diminution in the growth or yield of fruit or seeds, changes in physiological activities, metabolic activities and cellular structure, and deposit or accumulation of fluoride in the plant with increasingly higher concentration of fluoride in the tissues.

The Threshold Limit Value (TLV) for fluoride dust is 2.5 mg/M$^3$. The Federal Water Pollution Control Administration Water Quality Criteria recommends permissible limit criteria for fluoride in drinking water ranging from 0.8 mg/l to 1.7 mg/l, for average daily maximum temperature ranging from 50 to 90.5°F and recommends that water for livestock use contain less than 2.4 mg/l of fluoride ion. It also indicates a quality requirement of a maximum of 1 mg/l of fluoride ion in water intended for use by the canned, dried and frozen fruit and vegetable industry.

The Booz-Allen Ratings are:

|  | HUMAN |  |  | ECOLOGICAL |  |  | AESTHETIC |  |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 3 | 3 | 2 | 2 | 1 | 1 |

OTHER HAZARDS: Sodium fluoride and all ammonium and alkali fluorides are toxic to all life, yeast, other microorganisms, plant life, both harmful and beneficial, insects, fish and all higher vertibrates.

HANDLING, STORAGE, TRANSPORTATION: Care must be exercised when handling sodium fluoride to prevent contact with the skin or eyes, and to avoid ingestion of dust by inhalation or other means. Food should not be handled near any of the soluble fluorides. In case of contact the skin and eyes should be flushed thoroughly and medical attention obtained. Contaminated clothing should be removed and washed before re-use.

Sodium fluoride is shipped in screw cap bottles for quantities up to 5 lbs; for quantities from 5 lbs. to 400 lbs., polyethylene bag-lined drums or fiber drums are used. The containers should carry a "poison" warning label containing information on treatment and antidotes. The containers should be stored in a cool, dry area, and should be kept tightly closed.

In the disposal of sodium fluoride waste, the following Provisional Limits should be considered:

| NaF as a Contaminant | Provisional Limit | Basis for Recommendation |
|---|---|---|
| in Air | 0.025 mg/M$^3$ as F | 0.01 TLV |
| in Water and Soil | 0.8-1.7 ppm (mg/l) as F | Drinking Water Standard |

| EVALUATION OF WASTE MANAGEMENT PRACTICES: | EVALUATION |
|---|---|
| Two stage addition of lime slurry to waste containing tin and fluoride from plating. Discharge of fluoride stripped liquid to sewer. | Satisfactory |

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Dilution and reaction with slaked lime and soda ash and then neutralization with HCl, further dilution and discharge to sewers of the liquid and the sludge is added to landfill. | Satisfactory |
| Venting of fumes to the atmosphere. | Undesirable due to the pollution of the environment. |
| Direct discharge to sewers | Undesirable due to the pollution of the environment. |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Sodium fluoride is not considered a candidate waste stream constituent for National Disposal Sites. The above satisfactory procedures are not hazardous nor costly and are practical for waste generation site use.

# SODIUM HYPOCHLORITE

CHEMICAL FORMULA: NaOCl

GENERAL DESCRIPTION: Exists only in aqueous solution. Usually contains some sodium hydroxide. Strongly basic.

Molecular Wt.: 74.45 Melting Pt.: d Boiling Pt.: d
Density: (Liquid) --- (Gas) ---
Vapor Pressure: ---
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: d Cold Water: Soluble Ethanol: --
Other:
DOT Classification:
Coast Guard Classification:

MANUFACTURE: Reaction between sodium hydroxide solution and gaseous chlorine; electrolysis of a salt solution.

USES: Disinfectant and deodorant in dairies, creameries, water supply and sewage disposal; bleaching agent for cotton, linen, jute, paper pulp and oranges.

TOXICOLOGY: Not particularly toxic. No TLV established. Irritating to skin and mucous membranes.

OTHER HAZARDS: Oxidizing material. Contact with combustible material should be avoided. May ignite or explode when contaminated with organics or reducing agents.

HANDLING, STORAGE TRANSPORTATION: Avoid contact with reducing agents. Avoid exposure to heat. Skin contact should be avoided.

DISPOSAL/REUSE: Usually not processed for reuse, due to danger involved.

Provisional Limits for Disposal:

| Environment | Provisional Limit | Basis For Recommendation |
|---|---|---|
| In Air | 0.02 mg/M$^3$ | 0.01 TLV for NaOH |
| Water and Soil | 0.01 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Reduction by adding to large volume of | Satisfactory |

| DISPOSAL METHOD | EVALUATION |
|---|---|
| reducing agent. Release to sewer or stream | |
| Open burning | Not satisfactory; liberates HCl, $NO_x$ |
| Incinerator burning in gas flame. Vent scrubber | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Satisfactory on site disposal. Not a candidate for disposal at a National Disposal Site.

# SODIUM MONOXIDE

CHEMICAL FORMULA: $Na_2O$

GENERAL DESCRIPTION: White-grey, deliquescent, crystalline solid. Also called sodium oxide.
Molecular Wt.: 61.99 Melting Pt.: 920°C Boiling Pt.: 1275°C
Density: (Solid) 2.27 g/cc (Gas) (sublimes)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Decomposes Cold Water: Decomposes
Ethanol: Decomposes Other:
DOT Classification:
Coast Guard Classification: Hazardous material

MANUFACTURE: By controlled burning of sodium in air at temperatures less than 160°C

USES: No commercial use known.

TOXICOLOGY: Sodium monoxide is dangerous due to it caustic property. A Threshold Limit Value (TLV) has not been reported for this material, but NaOH which forms vigorously on contact of $Na_2O$ with moisture or human tissue, has a TLV of 2 mg/M3. The hydroxide is caustic in concentrated form, but neutralization with acid renders it harmless.

The Booz-Allen Ratings are:

| HUMAN | | | ECOLOGICAL | | | EXPLOSION | | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 2 | 3 | 1 | 2 | 3 | 0 | 1 | 2 | 2 |

OTHER HAZARDS: No other hazards known.

HANDLING, STORAGE, TRANSPORTATION: Sodium monoxide should be stored in cool dry, well-ventilated and preferably fire-resistant areas. Containers should be kept off of the floor, and away from any possible contact with water, combustibles and organic or readily oxidizable materials. Sodium monoxide being a strong caustic should be handled, loaded and shipped in the same manner as sodium hydroxide.

DISPOSAL/REUSE: For the safe disposal of sodium monoxide into the environment the following Provisional Limits are recommended:

| Sodium Monoxide as a Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.02 mg/M$^3$ as NaOH | Provisional Limit for NaOH |
| Water and Soil | 0.01 ppm as NaOH | Provisional Limit for NaOH |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Neutralized with $H_2SO_4$ in settling ponds and discharged into rivers | Satisfactory |
| When $Na_2O$ is in streams containing Na metal, it is treated the same as the metal which is dumped into the ocean in perforated drums or burned mixed with kerosene in a closed chemical reactor | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Since sodium monoxide waste is adequately handled at the industrial level, it is not considered a candidate for disposal at National Disposal Sites.

# SODIUM NITRITE

CHEMICAL FORMULA: $NaNO_2$

GENERAL DESCRIPTION: Yellowish or white crystalline solid. It oxidizes upon exposure to air. Also called diazotizing salt.
Molecular Wt.: 69.01 Melting Pt.: 271°C Boiling Pt.: 320°C
Density: (Solid) 2.168 g/cc (Gas) (Decomposes)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt.%): Lower Upper
Solubility:
Hot Water: 163 g/100 ml @ 100°C Cold Water: 72 g/100 ml @ 0°C
Ethanol: Slightly soluble Other: 0.3 g/100 ml in ether @ 20°C
DOT Classification: Oxidizing material, yellow label
Coast Guard Classification: Oxidizing material, yellow label

MANUFACTURE: By oxidizing into NO and passing the NO into a soda ash solution. The nitrate formed is separated by crystallization in lead lined equipment.

USES: In making dyes, in the preparation of nitric oxide, in pickling metal, in medicine, in rust proofing, in cutting oils and as food preservatives.

TOXICOLOGY: It is not highly toxic. In high concentrations in water it is irritating to skin and mucous membranes. No Threshold Limit Values have been recommended. The lethal Dose is reported as "or $LD_{50}$ 480 mg/kg rat".

The Booz-Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 1 | 2 | 3 | U | U | U | U |

OTHER HAZARDS: Sodium nitrite is both a reducing agent and an oxidizing agent. It is a fire hazard when in contact with organic or other easily oxidized material and is corrosive to most metals.

HANDLING, STORAGE, TRANSPORTATION: May be handled or stored as strong solutions in lead-lined containers.

DISPOSAL/REUSE: When in sufficient quantity, $NaNO_2$ can be reprocessed for reuse. The recommended Provisional Limits are:

| Sodium Nitrite in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.02* mg/M$^3$ | 0.01 TLV* |
| Water and Soil | 0.10* mg/l | Stokinger and Woodward Method |

* Estimated

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Dilution of the waste with large amounts of water containing soda ash and then adding calcium hypochlorite. Then neutralization with HCl, diluted and discharged to sewer or stream. Any sludge is added to Class 2 type landfill. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: This material has been classed as a probable waste stream constituent for municipal disposal and is not considered a candidate for treatment at a National Disposal Site.

## SODIUM SULFATE

CHEMICAL FORMULA: $Na_2SO_4$

GENERAL DESCRIPTION: White odorless crystals or powder.
Molecular Wt.: 142.06 Melting Pt.: 888°C Boiling Pt.:
Density: (Solid) 2.67 g/cm (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Soluble Cold Water: Soluble
Ethanol: Insoluble Other: Soluble in glycerin
DOT Classification:
Coast Guard Classification:

OTHER HAZARDS: When heated to decomposition sodium sulfate emits highly toxic fumes of oxides of sulfur.

TOXICOLOGY: Unknown.

# SODIUM SULFITE

CHEMICAL FORMULA: $Na_2SO_3$

GENERAL DESCRIPTION: White crystalline powder.
Molecular Wt.: 126.05 Melting Pt.: Decomposes Boiling Pt.: ______
Density: (Solid) 2.633 g/cc @ 15.4°C (Gas) ______
Vapor Pressure: ______
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (wt%): Lower ______ Upper ______
Solubility:
Hot Water: 28.3 g/100 ml @ 80°C Cold Water: 12.54 g/100 ml @ 0°C
Ethanol: Slightly soluble Other: ______
DOT Classification: ______
Coast Guard Classification: ______

MANUFACTURE: The most important commercial manufacturing process is the reaction of sulfur dioxide with a solution of soda ash. Another commercial source of sodium sulfite is as a byproduct from the preparation of phenol by the fusion of sodium benzene sulfonate with sodium hydroxide. Sodium sulfite is also recovered from paper mill cellulose waste liquors.

USES: It is used to bleach [illegible]ol and silk and as an "antichlor" after bleaching yarns, textiles and p[illegible] as a preservative for foodstuff and to prevent raw sugar solutions [illegible] coloring upon evaporation. It is also used in photography, medicine an[illegible] remove oxygen from boiler water.

TOXICITY: Sodium sulfite is not highly toxic. High concentrations are irritating to the skin and mucous membranes. No Threshold Limit Values have been established.

The Booz-Allen Ratings are:

| | HUMAN | | | BIOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 2 | 2 | 1 | 2 | 2 | 0 | 2 | 2 | 2 |

OTHER HAZARDS: Sodium sulfite is corrosive to most metals.

HANDLING, STORAGE, TRANSPORTATION: Strong solutions of sodium sulfite can be handled and stored in lead lined equipment.

DISPOSAL/REUSE: Industrially contaminated material when in sufficient quantity can be reprocessed for reuse.

For safe disposal of sodium sulfite into the environment, the following Provisional Limits are recommended:

| Contaminant in | Provisional Limit | Basis for Recommendation |
|---|---|---|
| Air | 0.02* mg/M$^3$ | 0.01* TLV |
| Water and Soil | 0.01* mg/l | Stokinger and Woodward Method |

*Estimated

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHODS | EVALUATION |
|---|---|
| Dilution with large volumes of water followed by reaction with soda ash, calcium hypochlorite and HCl then discharge into the sewer system. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Waste treatment for sodium sulfite can be handled adequately locally and is not considered to be a candidate for treatment at National Disposal Sites.

## STANNIC OXIDE

CHEMICAL FORMULA: $SnO_2$

GENERAL DESCRIPTION: White crystalline solid. Also called cassiterite.
Molecular Wt.: 150.70 Melting Pt.: 1127°C d Boiling Pt.: ______
Density: (Solid) 6.95 g/cc ______ (Gas) ______
Vapor Pressure: ______
Flash Pt.: ______ Autoignition Temperature: ______
Explosive Limits in Air (Wt%): Lower ______ Upper ______
Solubility:
Hot Water: Insoluble Cold Water: Insoluble
Ethanol: ______ Other: Decomposes in KOH & NaOH
DOT Classification: ______
Coast Guard Classification: ______

TOXICOLOGY: The dust of tin oxides have been known to cause pneumoconiosis which is usually benign.

## SULFURIC ACID

CHEMICAL FORMULA: $H_2SO_4$

GENERAL DESCRIPTION: Colorless, corrosive, oily liquid. Also called oil of vitriol and dipping acid.
Molecular Wt.: 98.08 Melting Pt.: 10.36°C (100%) Boiling Pt.: 338°C (98.3%)
Density: (Liquid) 1.834 g/cc (Gas) ________
Vapor Pressure: ________
Flash Pt.: ________ Autoignition Temperature: ________
Explosive Limits in Air (Wt%): Lower ________ Upper ________
Solubility:
Hot Water: Infinitely Cold Water: Infinitely Ethanol: Decomposes
Other: ________
DOT Classification: Corrosive liquid, white label
Coast Guard Classification: ________
MCA Warning label
IATA Classification: Corrosive liquid, white label;
1 liter (passenger) 5 liters (cargo)

MANUFACTURE:

USES: (1) 44% of the $H_2SO_4$ produced in the U.S. is used to manufacture superphosphate and phosphate-type fertilizers.
(2) 21% is used in the chemical industry.
(3) 10% is used in the petroleum industry.
(4) Other major uses are in the manufacture of titanium pigments, steel pickling, rayon, dyes, detergents, etc.

TOXICOLOGY: Sulfuric acid is very corrosive to all body tissues. Contact with eyes may result in total loss of vision and skin contact may produce severe necrosis. Inhalation of concentrated vapor may cause serious lung damage. Ingestion may cause severe injury and death.

The Threshold Limit Values (TLV) and Lethal Doses are:

| TLV | Lethal Dose or Concentration |
|---|---|
| 1.0 mg/M³ | ih $LC_{50}$: 510 mg/M³, rat<br>or $LD_{50}$: 2140 mg/kg, rat |

The Booz-Allen Ratings are:

| | HUMAN | | | ECOLOGICAL | | | EXPLOSION | |
|---|---|---|---|---|---|---|---|---|
| Air | Water | Land | Air | Water | Land | Air | Water | Land |
| 3 | 3 | 3 | 2 | 3 | 0 | 2 | 2 | 2 |

OTHER HAZARDS: Sulfuric acid is a powerful oxidizing agent and can ignite upon contact with combustibles. It also has a strong affinity for water, generating much heat in mixing.

HANDLING, STORAGE, TRANSPORTATION: Corrosive materials such as sulfuric acid must be handled carefully. Contact with the skin and inhalation should be avoided. It should be kept away from food and food products. Sulfuric acid should be kept tightly closed.

DISPOSAL/REUSE: For the safe disposal of $H_2SO_4$ into the environment the following Provisional Limits are recommended.

| $H_2SO_4$ as a Contaminant | Maximum Exposure Limit | Basis for Recommendation |
|---|---|---|
| In Air | 0.01 mg/M$^3$ | 0.01 TLV |
| Water and Soil | 0.05 ppm (mg/l) | Stokinger and Woodward Method |

EVALUATION OF WASTE MANAGEMENT PRACTICES:

| DISPOSAL METHOD | EVALUATION |
|---|---|
| Regeneration | Best choice when economically feasible |
| Neutralization with soda ash-slaked lime solution. The calcium sulfate is then removed by filtration. | Satisfactory |

APPLICABILITY TO NATIONAL DISPOSAL SITES: Sulfuric acid as a waste stream constituent is not considered to be a candidate for disposal at a National Disposal Site.

## TEREPHTHALIC ACID

CHEMICAL FORMULA: $C_6H_4(COOH)_2$ ;

GENERAL DESCRIPTION: White crystalline solid. IUC Name: 1,4 benzenedicarboxylic acid. Also called p-phthalic acid, TPA, and benzene-p-dicarboxylic acid.

Molecular Wt.: 166.13 Melting Pt.: Sublimes Boiling Pt.: Sublimes

Density: (Solid) 1.510 g/cc (Gas) ______ /approx 300°C

Vapor Pressure: ______

Flash Pt.: ______ Autoignition Temperature: ______

Explosive Limits in Air (Wt%): Lower ______ Upper ______

Solubility:

Hot Water: 0.0016 g/100 ml Cold Water: ______

Ethanol: Very slightly soluble Other: Very slightly soluble in ether and chloroform. Soluble in alkali.

Coast Guard Classification: ______

DOT Classification: ______

## THORIUM-230

CHEMICAL FORMULA: $_{90}Th^{230}$

GENERAL DESCRIPTION: Gray radioactive solid
Atomic Wt.: 230 Melting Pt.: 1845°C Boiling Pt.: 4500°C
Density: (Solid) 11.2 g/cc (Gas)
Type of Decay: Alpha Half-Life: 8 x $10^4$ years
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (wt%): Lower Upper
Solubility:
Hot Water: Insoluble Cold Water: Insoluble
Ethanol: Other: Soluble in HCl, $H_2SO_4$, and
aqua regia; slightly soluble in $HNO_3$
DOT Classification: Flammable solid, yellow label, 25 pounds
Coast Guard Classification: Flammable solid, yellow label
IATA Classification: Flammable solid, yellow label
Not acceptable (passenger), 12 kilograms (cargo)
Decays to radioactive radium-226 by emitting alpha particles.

FIRE HAZARD: Moderate, in the form of dust, when exposed to heat or flame or by chemical reaction with oxidizers.

HANDLING, STORAGE, TRANSPORTATION: Avoid, inhalation, ingestion or radiation exposure.

DISPOSAL/WASTE: For the safe disposal of Thorium 230 into the environment the following Permissible Concentrations should not be exceeded:

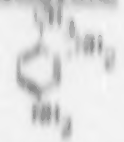
### MAXIMUM PERMISSIBLE CONCENTRATIONS

| Form | Concentrations in Air microcuries/milliliter | Concentration in Water microcuries/milliliter |
|---|---|---|
| Soluble | $8 \times 10^{-14}$ | $2 \times 10^{-5}$ |
| Insoluble | $1 \times 10^{-12}$ | $3 \times 10^{-5}$ |

## TOLUENEDIAMINE

### 2,4-TOLUENEDIAMINE

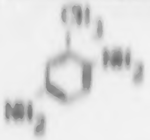
CHEMICAL FORMULA: $CH_3C_6H_3(NH_2)_2$,



GENERAL DESCRIPTION: Colorless crystalline solid. Also called tolylenediamine, 2,4-diaminotoluene and 2,4-toluylenediamine.
Molecular Wt.: 122.17 Melting Pt.: 99°C Boiling Pt.: 280°C
Density: (Solid) (Gas)
Vapor Pressure: 1 mm @ 106.5°C
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (v/v%): Lower Upper
Solubility:
Hot Water: Soluble Cold Water: Soluble
Ethanol: Very soluble Other: Very soluble in ether
DOT Classification:
Coast Guard Classification:
IATA Classification: Poison B, poison label
25 kilograms (passenger) 95 kilograms (cargo)

### 2,5-TOLUENEDIAMINE

CHEMICAL FORMULA: $CH_3C_6H_4(NH_2)_2$,



GENERAL DESCRIPTION: Colorless crystalline solid. Also called, 2,5-tolylenediamine, 2,5-diaminotoluene and 2,5 toluylenediamine.
Molecular Wt.: 122.17 Melting Pt.: 64°C Boiling Pt.: 274°C
Density: (Solid) (Gas)
Vapor Pressure:
Flash Pt.: Autoignition Temperature:
Explosive Limits in Air (v/v%): Lower Upper
Solubility:
Hot Water: Very soluble Cold Water: Very soluble
Ethanol: Very soluble Other: Very soluble in ether
DOT Classification:
Coast Guard Classification:

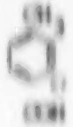
TOXICOLOGY: These materials can have a toxic effect upon the liver, causing fatty degeneration. They are though to be irritant. Upon contact with the skin they can cause irritations and blisters. 2,5-Toluenediamine can also be toxic to the central nervous system, produce jaundice by its action on the liver and spleen and produce anemia. It can also produce permanent injury to the eye.

OTHER HAZARDS: They are moderate fire hazards when heated they emit highly toxic fumes.

HANDLING, STORAGE, TRANSPORTATION: Store in a cool, well ventilated area away from heat and flames. Avoid contact with the skin or eyes. Avoid inhalation and ingestion.

## para-TOLUIC ACID

CHEMICAL FORMULA: $CH_3C_6H_4COOH$,



GENERAL DESCRIPTION: White crystalline solid. Also called para-methylbenzoic acid.

Molecular Wt.: 136.14 Melting Pt.: 179.6°C Boiling Pt.: 275°C

Density: (Solid) ______ (Gas) ______

Vapor Pressure: ______

Flash Pt.: ______ Autoignition Temperature: ______

Explosive Limits in Air (Wt%): Lower ______ Upper ______

Solubility:

Hot Water: 1.26 g/100 ml @ 100°C Cold Water: 0.034 g/100 ml

Ethanol: Very soluble Other: Very soluble in ether

DOT Classification: ______

Coast Guard Classification: ______

## URANIUM

CHEMICAL FORMULA: U

GENERAL DESCRIPTION: Silver white or black crystals. There are four natural isotopes; U232, U234, U235 and U238 and four artificial isotopes; U230, U233, U236 and U240
Atomic Wt.: 238.07 Melting Pt.: Approximately 1133°C Boiling Pt. Ignites
Density (Solid) 18.7 g/cc
Solubility:
Cold Water: Insoluble Hot Water: Insoluble Ethanol: Insoluble
Other: Soluble in acid, insoluble in alkali

The radioactive decay of the isotopes are:

| Isotope | Half-life | Emissions Particle | Radiation Energy Level and Intensity | Decays to |
|---|---|---|---|---|
| U230 | 20 days | alpha | 5.8-5.9 MeV | Th-226 |
| U232 | 74 years | alpha | 5.3 MeV | Th-228 |
| | | gamma | 0.06 MeV | |
| U233 | 1.6 x $10^5$ years | alpha | 4.8 MeV | Th-229 |
| U234 | 2.5 x $10^5$ years | alpha | 4.7-4.8 MeV | Th-230 |
| U235 | 7 x $10^8$ years | alpha | 4.3-4.6 MeV | Th-231 |
| U236 | 2.4 x $10^7$ years | alpha | 4.5 MeV | Th-232 |
| U238 | 4.5 x $10^9$ years | alpha | 4.2 MeV | Th-234 |
| U240 | 14 hours | beta | 0.36 MeV | Np-240 |

DOT Classification: Poison D, radioactive materials, red label.
IATA Classification: Radioactive material, red label
2000 millicuries (passenger and cargo)

TOXICOLOGY: The high chemical toxicity of uranium and its salts is largely shown in kidney damage and acute necrotic arterial lesions. Relatively large amounts tend to be taken in due to the rapid passage of soluble uranium compounds through the body. The highly toxic effect of insoluble compounds is largely due to lung irridation by inhaled particles.

This material is transferred from the lungs of animals quite slowly.

OTHER HAZARDS: A fire hazard in the form of a solid or dust when exposed to heat or flame and an explosion hazard when the dust is exposed to flame.

HANDLING, STORAGE, TRANSPORTATION: Avoid inhaling the dust, ingestion or exposure to radiation. Store away from fire and flame in a way to prevent exposure to personnel.

DISPOSAL/REUSE: For the safe release of uranium into the environment the following Permissible Maximum Concentrations should not be exceeded:

## MAXIMUM PERMISSIBLE CONCENTRATIONS

| Isotope | Form | Concentrations in Air (microcuries/milliliter) | Concentration in Water (microcuries/milliliter) |
|---|---|---|---|
| Uranium 230 | Soluble | $1 \times 10^{-11}$ | $5 \times 10^{-6}$ |
| | Insoluble | $4 \times 10^{-12}$ | $5 \times 10^{-6}$ |
| Uranium 232 | Soluble | $3 \times 10^{-12}$ | $3 \times 10^{-5}$ |
| | Insoluble | $9 \times 10^{-11}$ | $3 \times 10^{-5}$ |
| Uranium 233 | Soluble | $2 \times 10^{-11}$ | $3 \times 10^{-5}$ |
| | Insoluble | $4 \times 10^{-12}$ | $3 \times 10^{-5}$ |
| Uranium 234 | Soluble | $2 \times 10^{-11}$ | $3 \times 10^{-5}$ |
| | Insoluble | $4 \times 10^{-12}$ | $3 \times 10^{-5}$ |
| Uranium 235 | Soluble | $2 \times 10^{-11}$ | $3 \times 10^{-5}$ |
| | Insoluble | $4 \times 10^{-12}$ | $3 \times 10^{-5}$ |
| Uranium 236 | Soluble | $2 \times 10^{-11}$ | $3 \times 10^{-5}$ |
| | Insoluble | $4 \times 10^{-12}$ | $3 \times 10^{-5}$ |
| Uranium 238 | Soluble | $1 \times 10^{-12}$ | $4 \times 10^{-5}$ |
| | Insoluble | $5 \times 10^{-12}$ | $4 \times 10^{-5}$ |
| Uranium 240 | Soluble | $8 \times 10^{-9}$ | $3 \times 10^{-5}$ |
| | Insoluble | $6 \times 10^{-9}$ | $3 \times 10^{-5}$ |
| Uranium (nat) | Soluble | $1 \times 10^{-12}$ | $2 \times 10^{-5}$ |
| | Insoluble | $2 \times 10^{-12}$ | $2 \times 10^{-5}$ |

## VALERIC ACID

CHEMICAL FORMULA: $CH_3(CH_2)_3C(=O)OH$

GENERAL DESCRIPTION: Colorless liquid. Unpleasant odor. IUC Name: Pentanoic acid.

Molecular Wt.: 102.13 Melting Pt.: -34.5°C Boiling Pt.: 187°C
Density: (Liquid) 0.942 g/cc @ 20°C (Gas)
Vapor Pressure:
Flash Pt.: 205°F (O.C.) Autoignition Temperature:
Explosive Limits in Air (Wt%): Lower Upper
Solubility:
Hot Water: Cold Water: 3.7 g/100 ml @ 16°C
Ethanol: Infinitely Other: Infinitely soluble in ether
DOT Classification:
Coast Guard Classification:

TOXICOLOGY: Probably a moderate toxic and high irritant based on animal experiments.

OTHER HAZARDS: Fire hazard when exposed to heat and flame and can react with oxidizing materials.

HANDLING, STORAGE, TRANSPORTATION: Avoid breathing of fumes and skin contact. Store in a cool well ventilated area, away from heat, flames and oxidizing materials.

# SECTION XI

## APPENDIX C

## REFERENCES CITED

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